THE PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

Vol. XXXIII, No. 1. MARCH, 1907. Whole No. 121.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

PRIZE ESSAY.

STOREKEEPING AT THE NAVY YARDS.

By PAY INSPECTOR JOHN A. MUDD, U. S. Navy.

Motto: With a long pull and a strong pull,
And a pull all together.

There is no room in such a paper as this for historical review. Sufficient is it to state that, since the naval establishment was inaugurated, there have been a number of systems of obtaining supplies, caring for them in government store, and finally issuing them for use. Up to the present one, none had been devised with much thought of economic conditions in relation to the general government. Finally, a young business man became Secretary of the Navy at an opportune time; old moss-covered methods were looked at askance; and a radical change was made. The result was the present system of keeping the navy's big store.

The change was made under protest, grounded not on the belief that the new organization was radically defective, but on the fact that the various branches of the naval establishment were to lose control of the care and issue of the supplies of which they had cognizance. The new organization has survived some tempestuous times; long ago it would have become an abandoned wreck, had

not the commanding power, the civil Secretary of the Navy, quelled the mutinous crew with the mailed fist of authority. The uprisings were put down because this supreme authority, with its mind free from the traditions and prejudices of the service, knew that the change pointed in the right direction,—towards business-like administration of a business branch of the naval establishment, and also towards wise general economy.

The new system, although well equipped mentally, was born with a curse, that, although alleviated a little since birth, has not been cured. This deformity is the binding tissues to the bureau system of the Navy Department.

For several years the workers under the new organization plodded on, striving for satisfactory results under this handicap. But the ideal remained out of sight, and would not have come in view at all if it had not been for the creation of what is called the naval supply fund. In this fund was found the road along which we might travel towards a goal. But the means provided for progress along this way to success are already inadequate. The naval supply fund should be increased to four times its present amount; then, if we do our duty all the time, there will, in short order, be a quick and reliable working system of storekeeping at the disposal of the navy, and a businesslike economy to satisfy the public. Every increase of the fund makes the pernicious power of bureau control of supplies in store less felt, and real *general* storekeeping nearer a fact. By this reference to the bureaus, no slur upon the present departmental organization is intended. The writer is simply pointing to the handicap of supplies being purchased and kept in store under so many appropriations.

THE DIFFERENCE BETWEEN STOREKEEPING UNDER THE NAVAL SUPPLY FUND AND THAT UNDER THE BUREAU APPROPRIATIONS.

The naval supply fund is a sum of money voted by Congress to be held apart in the Treasury for the purchase of supplies for the navy and to be reimbursed from the current naval appropriations, at the time the supplies are drawn from the naval store for actual use. The fund is continuous. Its debits are the public bills prepared in payment for the supplies purchased from the commercial world, and its credits, the transfer statements of the general storekeepers, showing issues of the stock on account of the various

current appropriations to be debited. The fund was created in 1893, Congress setting aside a few thousand dollars. It has since been increased several times, being now $2,700,000.

A great difference in status exists, in the general storekeeper's warehouses, between supplies purchased directly under bureau appropriations and those purchased under the naval supply fund. The former are paid for from some current naval appropriation at the time of purchase from the commercial world, and, when actually drawn from the navy yard store for use, entail no further deduction from an appropriation; while the latter, when drawn for use by the navy yard departments or ships in commission, from the general storekeeper's stock, mut be paid for *then,* from the funds of some current appropriation. In the latter case, the money deducted from the appropriation is transferred to the credit of the continuous and ever turning over naval supply fund, which paid for the supplies at the time they were purchased from the commercial world.

The quantity, style, and quality of the supplies purchased from the commercial world, under the bureau appropriations, are controlled practically by the various bureaus having cognizance. The quantity of the supplies purchased under the naval supply fund is controlled by the Bureau of Supplies and Accounts,—at present, within the narrow limitations of a stock that must not exceed $2,700,000 in value. The style and quality of the naval supply fund stock are controlled, to a large extent, by standard specifications, approved by the various bureaus interested. Where standard specifications do not exist, style and quality are determined by the advice of the bureaus interested. The chief of the Bureau of Supplies and Accounts and his representatives, the general storekeepers, determine nothing of this. There is no flaw to pick in this detail of naval supply work. Everyone concerned knows that each bureau interested has always had its proper part in the control over style and quality of the naval supply fund stock.

THE ECONOMY OF GENERAL STOREKEEPING UNDER THE NAVAL SUPPLY FUND.

To partly illustrate the economy of the naval supply fund as compared with the system of direct purchase from the commercial world, under the current bureau appropriations, an article, in constant use by all branches of the establishment at a navy yard,

will be selected and followed in its course through both systems. White lead will answer the purpose. The scene of the exposition will be a certain small navy yard, in regard to which the writer has reliable figures. At this yard, where about one thirty-fifth of the aggregate work done at the principal eight yards is accomplished, there were used in a year 45,700 pounds of white lead. This quantity was used by the various yard departments as follows:

Construction and Repair	35,000 lbs.
Yards and Docks	5,000 "
Steam Engineering	3,000 "
Equipment	1,500 "
Ordnance	500 "
Medicine and Surgery	200 "
Supplies and Accounts	200 "
	45,400 lbs.

rounding off the figures in the detail.

Suppose now that the naval supply fund did not exist. In order to stock up with white lead at this yard, seven purchase requisitions would have to be prepared. Purchase requisitions are made in quadruplicate, by the yard departments concerned, under the most exacting and time-consuming regulations in regard to specifications, estimates, certificates, etc. There is at least one clerk in each deparment of size constantly employed on this work. After preparation, the requisitions are sent to the general storekeeper for checking against stock on hand, to verify the yard department's previous check, and for recording and signing. From each one of these requisitions, represented by a specially opened " folder," is built up, in the general storekeeper's office, a case. On each case lodge all the papers and correspondence pertaining to the requisition, and on the folder is kept an exhaustive record of the steps of purchase. Some of these cases swell in time to volumes, before they become finished business, and the handling of them consumes a large quantity of clerical labor in the general storekeeper's office. From that office the seven requisitions for the white lead would pass to the commandant's office, for record and approval, and from there they would be forwarded to Washington, to the bureaus concerned, where once again they would proceed to consume large quantities of clerical labor. After examination, record and approval in the bureaus, the requisitions are

passed to the purchasing bureau, that of Supplies and Accounts, where there are expended over them more units of clerical labor than the aggregate in all the preceding steps. Then comes advertising and the bureau contracts, or navy pay office purchase under formal, written contract or in the open market,—a separate operation for each of the seven requisitions, unless by the merest chance two or more are forwarded from the yard by the same mail. Here is indeed mighty expenditure of clerical labor.

Referring back to the quantities of white lead used during a year by the various yard departments at the small yard taken as an example, it is likely the quantities called for under the seven requisitions would be about as follows:

Construction and Repair	40,000 lbs.
Yards and Docks	1,000 "
Steam Engineering	4,000 "
Equipment	1,000 "
Ordnance	500 "
Medicine and Surgery	200 "
Supplies and Accounts	200 "
	46,900 lbs.

These figures are not mere guess work, but are based on experience.

The prices paid on the seven requisitions would likely be close to the following, comparatively speaking:

Construction and Repair	40,000 lbs.	at	.055	$2,200.00
Yards and Docks	1,000 "	"	.07	70.00
Steam Engineering	4,000 "	"	.0625	250.00
Equipment	1,000 "	"	.07	70.00
Ordnance	500 "	"	.07	35.00
Medicine and Surgery	200 "	"	.0725	14.50
Supplies and Accounts	200 "	"	.0725	14.50
	46,900 lbs.			$2,654.00

The average price per pound of the total would then be .056588.

There would be at least seven deliveries at the yard, to make up this aggregate of 46,900 pounds of the seven requisitions, entailing at least seven inspection calls, with the attending work and papers. After being passed into stock, there would be seven public bills, in triplicate, prepared. Each of these public bills would involve the full work of the routine progress through the general

storekeeper, commandant, bureau concerned, paymaster general, and purchasing pay officer, and its separate disbursement officer's check, in settlement. In the navy yard storehouse the white lead would have to be placed in seven different lots, each with its own tally card, and in the bookkeeper's room seven different ledger accounts would be involved. Separated into seven lots, the stock would take up twice as much space as if packed in one compact lot. Also, the storemen would have to be seven times as watchful in the case of this divided stock than in the case of one general pile of the material, from which issues could be made indiscriminately.

Now a great change comes. The naval supply fund is created, and white lead is one of the items carried under it at the small navy yard of example. The yard departments no longer make purchase requisitions for it. Instead, when it is needed, they send to the general store and draw out the *required* quantity on a "stub requisition" (which is a store order), the same paper that was necessary in drawing their own stock from store, in the days of the bureau purchase requisitions. So *all* the clerical labor and other expense in the yard departments that were formerly necessary in preparing purchase requisitions are entirely eliminated.

The general storekeeper has a "limit" on the white lead stock. This limit is the number of pounds below which he considers it unsafe to allow the stock on hand to fall, before taking steps to obtain additional quantity. The general storekeeper makes but one request a month on the Bureau of Supplies and Accounts (except in emergencies) for replenishing the naval supply fund stock. When it is time for this monthly request, all stock tally cards are examined, and the request comprises all items of stock on hand below, or near the limit mark. He counts on buying white lead twice a year. The limit has been fixed at 19,000 pounds, about a five months' issue (see page 24). When the quantity in store gets near that mark, the next monthly request bears, among perhaps hundreds of items, the item "23,000 pounds white lead," half the quantity used in a year at the yard. The request is prepared in duplicate, *not quadruplicate,* as in the case of each of the seven purchase requisitions just alluded to, and it requires none of the elaborate specifications, certificates, etc., of the purchase requisition, and needs only the signature of the general storekeeper, and the forwarding stamp of the commandant's office, before being

started on its journey direct to the Bureau of Supplies and Accounts. After each item entered on it is written the reference number of the standard specification governing,—that is all. The items go into the next advertisement schedule issued by the Bureau of Supplies and Accounts: the white lead is purchased in one lot, comes to the yard in, say, one delivery, requiring one inspection, and finally passes into store in one pile, from which it is sold to the yard departments as they actually need it. The only paper required of the yard departments in this transaction is, as stated before, the stub requisition, which would have been necessary even if the white lead had not been carried under the naval supply fund. There is but one public bill prepared in the general storekeeper's office, in settlement for this white lead, and this unity of transaction goes right through until the one merchant receives the one check and the whole affair becomes finished business. The mass of papers, stored away in the general storekeeper's file room, is about one-seventh the size of what was put there after stocking up with white lead under the system of purchasing directly from the commercial world under the current bureau appropriations.

Supposing the white lead purchased under the naval supply fund cost five and a half cents per pound, the bill for the 23,000 pounds would be $1265.00. A similar quantity purchased from the aggregate of the seven purchase requisitions would have cost, at the average price of .056588, $1301.52, thus involving a loss, *by prices alone*, of $36.52 to the government. The navy also would have, under the seven purchase requisitions transaction, a surplus stock, a useless stock for the time being, of 23,900 pounds of white lead, the difference between the aggregate of the seven purchase requisitions, 46,900 pounds, and the half yearly request for 23,000 pounds under the naval supply fund. This would require extra storage room, involving contingent expenses for care, etc.

At the navy yard of example, where about one thirty-fifth of the work of the principal eight yards is done, we find the supplying of white lead by direct purchase from the commercial world involved a loss of $36.52 as compared with the cost of the naval supply fund method of storekeeping. If thirty-five times as much white lead was required for the principal eight yards as at the yard of example, and all eight places were to stock up at the same time under the system of direct purchase under current bureau

appropriations, there would be a loss to the government, on account of prices paid, of $1278.20, and there would be an unnecessary stock on hand of 23,900 times 35, which would be 836,500 pounds of this one item among thousands,—this unnecessary stock occupying valuable storage space, and tying up $47,335.76 of the government's money.

White lead is but one item among thousands carried in stock at a yard, and it is not a particularly good item for the writer to have selected for making his argument. It is hoped the student of this paper will read here more than is printed. The writer in many cases will try only to point the way. At the risk of being tiresome with the white lead example, he has tried to show, without exaggeration, that storekeeping under the naval supply fund is more economical for the government than the present method of a storehouse divided against itself, as it were, and that under it, the navy gets as good a quality and style of supplies as it got in any other way. This example, by itself, is not put forward as a mathematical certainty; simply a convenient way of demonstrating by pictorial steps the superiority of storekeeping under the naval supply fund. All those experienced in such matters know the assumed data of the seven purchase requisitions for white lead fairly represent the truth, taking as a whole the system of storekeeping by direct purchase under bureau appropriations.

An economic advantage that would come in full with an adequate naval supply fund would be the ability to purchase, under one contract, in a lump lot for delivery at a certain yard, the total supply of an article needed for all the yards during a certain period, and then distribute from the point of delivery to other yards as needed. The lower prices obtained in this way would often offset the freight charges of distribution, fewer papers and units of clerical labor would be involved, and a uniform quality would be obtained for the entire service. Also, if delivery were made at the New York yard, better inspection would be had. The Bureau of Supplies and Accounts is practicing this to an extent, limited by the size of the fund. All shellac used in the service is bought this way, delivered at New York, and required from there by the other yards. It is the same with writing, copying, and blotting paper. As the fund increases in amount, this power increases in extent. Concentration in purchasing makes for economy in administration. And it might be remarked here that re-

form in administration at the buying end of our business is much more telling for economy than reform at the issuing end, for many more papers and units of clerical labor are used in getting supplies into stock than in taking them from stock, for use.

A PROPOSITION FOR ENLARGING THE NAVAL SUPPLY FUND.

On July 1, 1905, there was, in the aggregate, at the principal nine navy yards (Portsmouth, Boston, New York, League Island, Washington, Norfolk, Mare Island, Puget Sound, and Cavite) $42,500,000 worth of supplies in stock, excluding naval supply fund stores and provisions and clothing, and rounding off the figures. $27,500,000 of this amount was represented by fuel and technical ordnance material, deducting which from the total just mentioned, would leave $15,000,000. It has been carefully calculated, from reliable data, that, of this last amount, $4,000,000 was represented by a class of material that it would not be wise, or at least necessary, to carry under the naval supply fund, such as instruments of precision, machines, heavy ground tackle, boats, and a lot of other ship equipage, etc. Deducting this amount from the last remainder, we have $11,000,000. It is guessed that about one-third of this last amount was represented by obsolete and worthless stuff, stock on hand in excess of requirements, and difference between excessive prices borne on the ledgers and market prices. Calling this $3,500,000 and deducting it, we have left $7,500,000, which represents the amount by which the naval supply fund should be increased to satisfy the demands of the principal nine yards. The value of supplies on hand, July 1, 1905, outside these yards was $6,000,000. Reducing this in the same proportion as the sums just handled, would leave $1,000,000 as necessary for the fund at the smaller yards and stations. Add this to the $7,500,000 just obtained and we have $8,500,000, which may be called the amount by which the fund should be increased, to satisfy the requirements of the entire service. As the fund is now $2,700,000, it can safely be said, with a naval supply fund of $11,000,000 the navy can be kept supplied with all commercial material and can have as near a perfect *general* stores system as will be possible under the conditions in sight.

The fund, as stated, is now $2,700,000. How increase it towards the estimated $11,000,000? Congress seems stubborn towards any further setting aside of money for the purpose. All recent

efforts have met with failure. At the bottom of this action is, no doubt, fear of giving the navy additional facilities for overstocking, for the members of the naval committees understand by this time that the fund is not an "appropriation." The writer has long had in mind a scheme for the proper increase of the fund, but has not advanced it, thinking opposition the suggestion would probably meet from some of the bureaus would kill it. But there have been favorable signs in the sky of late, and, with some hope of success, the proposition, will be made here.

At a set date, turn over to the fund all general stock (stock that has been purchased directly from the commercial world under current bureau appropriations) fit for use in the active work of the navy, and which has not been purchased for definite work that is actually in hand at the date set. And thereafter, when any of the jobs for which stock has been reserved are completed, turn over to naval supply fund stock remaining material. The transfer to the fund should be made, of course, at current market prices, where the ledger prices are excessive. From this transfer, exclude articles of a purely technical naval nature that are used practically by but one bureau, building material used exclusively by the department of yards and docks, and fuel. After this transfer, all increase navy stock that is not in store for use on a ship or its equipment not completed should be *bought* by the naval supply fund. This latter transfer might or might not run the fund in debt to "increase navy," for lack of ready cash; but that obligation would soon be settled. After this first transfer of increase navy stock all remnants of the stock held for ships and their equipage not completed should be bought by the fund as soon as completion and commission of the ships concerned.

Under the proposed transfer of common general stock to the naval supply fund it is problematical what the fund would amount to after the transfer was accomplished. This lack of precise knowledge is nothing to bother over now. If the fund still remained considerably under the required $11,000,000 Congress no doubt, under the influence of the navy's generous move, would at last help out with some more cash. If, on the contrary, the fund was found to be considerably over $11,000,000, Congress, after allowing us time to shake down and find out where we were, could lop off a piece. According to the writer's deductions, just shown, the fund after the transfer, etc., would be under the

required amount, for he provides in his scheme for the ultimate purchase of all common increase navy stock, and not its transfer to the fund without reimbursement of the increase navy appropriations.

"Increase Navy," as a separate stock "account" in the bookkeeping system of the supplies department, should be abolished, and the supplies now carried under it, that are not sold to the naval supply fund, transferred to general stock (Account a). There never was good reason for the existence of this separate account. There has been a feeling among those in control that Congress was going to ask, some day, how much increase navy stock there was on hand at the yards, and that alone, the writer believes, is the reason this separate increase navy store, within the general store, has been kept up, with its attendant books, papers, and clerical work. Let Congress ask the fearful question. It will be all right. The answer can at once be picked out of stock ledgers at the various yards. For if the increase navy stock were transferred to general stock, separate itemized ledger accounts and tally cards would be maintained, and the stock kept separated on the shelves of the store, just as is done now in the case of general stock purchased for a particular purpose.

Common general and increase navy stock, of the kind mentioned for transfer, that would not be transferred under the proposition, on account of being obsolete or in poor condition, should be surveyed, with a view of condemning for sale. No part of this remaining stock should be "hoarded." Storage room is valuable.

Bear in mind that the yearly general appropriations are intended for the support of the navy *for one year*. If Congress gives money for building ships, procuring reserve guns and ammunition, etc., the appropriations are separate items in the naval bill. The regular annual bureau appropriations have not been intended by Congress for use in storing vast quantities of reserve supplies at the yards. They have been used for such purpose, though, towards the end of the fiscal year, with large balances on hand. This waste or tying up of government money has done the navy, as a whole, more harm than it has done good to the individual bureaus who have thought to gain an advantage. This useless stocking up is an old, familiar subject in the naval committee rooms at the capitol.

If this idea for enlarging the naval supply fund should ever be considered by the Department, it is hoped it will not be opposed by the technical bureaus for the reason alone that they do not want to pay a second time for the supplies originally bought under their regular appropriations. What they really will be paying for is a sane, efficient system of storekeeping from which, in the end, they are certain to benefit immensely. And they should reason that the sacrifice, if any, is necessary on account of sins of the past, which now make Congress say "nay, nay," when we knock at the door with our request for a money allotment increasing the fund.

It is true the fund has been increased since its creation, but in the past few years, in spite of strong and what should be convincing arguments, Congress has shown itself stubborn towards further increase. At the bottom of this is undoubtedly the tradition of the overstocking of yards. Sometimes ignorance, on the part of some in the naval committees, of the real purpose of the fund is one cause, but not the principal.

Now, if the navy comes to Congress and says that it is willing to turn over several million dollars worth of supplies, which have already been paid for from past annual appropriations, to the naval supply fund, in order to increase the efficiency of the fund, and thus make nearer possible a businesslike, and therefore economical storekeeping system, Congress will exclaim, "Larks me! the skies must be falling," and then, we hope it will say, "Go ahead. The sooner the better."

Should the navy move Congress in this way, it would want to accomplish one other important thing, and that is to provide against the constant drain from the fund, on account of deterioration of stock, etc. There is no provision whatever now. This could be done by turning over to the fund the proceeds from public sales of condemned naval material, except clothing, which itself is carried under a fund. This should be provided for in the same bill authorizing the transfer of the surplus general stock to the naval supply fund. As the law stands, proceeds from sale of ordnance material, up to a certain limit, are credited to a current appropriation of the Bureau of Ordnance; the proceeds from clothing and small stores, to the fund for those articles; and all other sales money goes to the general fund of the treasury, the navy deriving no benefit. During the year 1905, $203,307.48 was received from the public sale of condemned property. Of this sum,

$84,510.73 went to the credit of the Bureau of Ordnance, $21,666.86 to the credit of the clothing and small stores fund, and the balance, $97,129.89 left the navy and went back into the general fund of the treasury.

With the naval supply fund increased to the amount argued for in this paper, the bureaus should not be allowed to purchase under their appropriations, directly from the commercial world, any items that are habitually carried in store under it. In emergencies, when the stock of any item becomes exhausted, purchase in the open market should be made under the fund. And right here, the writer will imagine what is being thought by some who have had experience in yard department work. That is, that the general storekeepers will not keep the stock up to meet the demands. The answer to this is that if the Bureau of Supplies and Accounts can not provide, for the duty, general storekeepers with intelligence and application enough to keep stock up to requirements, that is, as near to the requirements as zealous foresight and complete system can accomplish, then get the Secretary to appoint line officers or naval constructors or civil engineers or civilian clerks general storekeepers, and eliminate this, the most important duty the pay corps performs, from its tasks; but do not wrong the navy and the government by stunting the growth of a fine general stores system because the particular workmen in mind are considered incapable of administering it.

Congress may say to us, "What is to prevent yard departments from overstocking even under the enlarged naval supply system; that is, expending useless balances of annual appropriations, towards the end of a fiscal year, for naval supply fund stores that are not needed in the departments at the time, and for excess supply of articles exempt from the naval supply fund stock?" Nothing will prevent this being done to an extent, with naval supply fund stock, unless we institute more stringent regulations. The spirit of the regulations permits no storehouse in a navy yard other than the general stores, in charge of the general storekeeper, and also directs that supplies be drawn from store by the yard departments for use only on specific jobs underway at the time, and only in such quantities as necessary to keep the jobs going properly. The writer will admit that with present customs, ideas, and ignorances there would be danger in instances, where yard departments had unexpended balances placed at their

disposal towards the close of a fiscal year, of the drawing of quantities of naval supply fund stores not really needed at the time, from the storehouses and putting them away against a rainy day. But we of the navy, as a whole, ought to be able to prevent such zealous action on the part of a few of our brothers, who work within a contracted mental horizon. The following roughly suggests a plan that would probably prevent this:

At the end of each fiscal year require the head of each department at each yard and station to submit an itemized list of quantities, with value, of material, drawn from store, on hand in the department. This list should have on it the date each item was drawn from store, the job order number under which drawn, with a detail of the order, and the probable time of the completion of the jobs. The list to be closed with a *certificate* by the head of department that the items listed cover all supplies actually within the jurisdiction of the deparment at the close of the last day of the fiscal year, and that amounts listed are considered necessary for completing the jobs *under which they were drawn from store.* The lists to be transmitted by the commandant first to the general storekeeper for examination and comment, and then to the Bureau of Supplies and Accounts, through the bureau concerned.

As to overstocking with the class of supplies exempted, in the proposition, from the enlarged naval supply fund, there is little danger. Honest officers would not burden the navy with a useless and highly expensive lot of compasses, barometers, machine lathes, and other instruments and machines that might deteriorate with disuse and which would be liable to damage. The man who might unblushingly lay in a ten years stock of commercial steel bar in the month of June, with the aid of an unexpended balance, would not think of buying several hundred mercurial barometers with the same money, if he could.

The following list, although not exhaustive by any means, will show more fully the class of articles that the writer would have exempted from even the enlarged naval supply fund proposed, and which would be purchased or manufactured directly under the bureau appropriations:

Ordnance material, fuel, navigation and survey instruments, sails, awnings, screens and tarpaulins, boats and outfits (with some exceptions), rigging of all kinds, sideboards, tables, bookcases, and other articles of ship's furniture usually manufactured

at navy yards, ship's anchors and cables, and some other articles of ground tackle, photographic outfits, machinery and machine tools of a character that is purchased only when actually wanted for use, curtains and fittings and rugs of a ship's outfit, drawing instruments, fodder, harness, ranges and galleys (but not spare parts), printing outfits, masts and other spars, etc.

With the adequate naval supply fund suggested, stores turned in from ships placed out of commission could be handled as follows: Articles habitually carried under the fund, that are considered by the general storekeeper as fit for issue, take into the naval supply fund stock, and at the current ledger price, in case the invoice price exceeds it, charging difference to waste. Credit the appropriation of the bureau turning in the stores with the value of the articles as taken up (if legalized), and debit the naval supply fund with the same amount. Survey the articles, habitually carried under the fund, not considered fit for active naval supply fund stock, and any such articles afterwards repaired by a yard department, take into naval supply fund stock, at the current ledger prices, if the general storekeeper considers them fit.

The adequate enlargement of the naval supply fund would do away practically with the tedious time-consuming matter of the transfer of appropriations on account of supplies purchased under one bureau being used, during the fiscal year in which bought, by another bureau. It happens often at a yard that a department needs, at once, supplies in stock that have been purchased, during the current fiscal year, under an appropriation of a bureau other than the one the department represents at the yard. In such a case the supplies can not be used without the consent of the head of the department having cognizance of them. With this consent, the general storekeeper, after issuing them, must make a record for the proper crediting of the appropriation under which the supplies were purchased, and the debiting of the proper appropriation, the one pertaining to the yard department drawing them from store. At the end of each month the general storekeeper sends to Washington a detailed, tabulated statement showing necessary transfers between appropriations, covering such cases during the month. This statement must be accompanied by a voucher for each case stated. The same papers are as necessary for a pound of nails as for a thousand pounds of copper ingot. At a large yard there are hundreds of such transfers each month

and they all concern the kind of stock that it is recommended in this paper be carried under an enlarged naval supply fund. After the transfers and accompanying vouchers reach Washington there is much work in the Bureau of Supplies and Accounts with the liability books, and then further work in the Treasury Department, in actually making the credits and debits to the many appropriations involved. With the proposed $11,000,000 naval supply fund this work will be practically eliminated, and, therefore, many units of clerical labor saved to both the navy and the treasury.

The gradual enlargement of the naval supply fund has been through no policy settled in advance, but it has likely, after all, acted for the best interests. Through the naturally ignorant and experimental stages of its administration we have not been able to do the amount of damage that might have occurred had an adequate fund been created at one time.

Almost immediately after the first allotment of a few thousand dollars for the fund there was bought under it, at one of the principal yards, a quantity of horse-shoe nails. Yards and Docks soon after changed its style of head or horse or something, and refused to use the nails in stock under the fund. There being no particular call for them from the fleet, they became a dead loss to the fund.

Sometime after this, the supplies department entered into diplomacy, and in order to bring round a big man to its side on some question of supplies or accounts, consented to keep all the rigging blocks of the navy under the fund. The block makers at the various yards then began to turn out little blocks and big blocks and middle blocks so fast that soon, in order to save a few dollars of the fund for other purposes, and to keep the stock of blocks on hand down under a hundred years supply, we had to cry "enough!" to the big man. And we, who did it, concluded it was long-eared policy to use the fund as a diplomatic lever. Fortunately, the big man was kind and bought all the blocks back again from the fund,—for a concession.

Then it was found that, following the advice of our brothers, the officers of the yard departments, we were saddled under the fund with quantities of certain sizes of fittings, etc., that did not turn over as fast as healthy stock should, and we accordingly learned to scrutinize *closely* our brothers' lists, before ordering the goods. One of the leading causes of overstocking and the ac-

cumulation of some articles not used at all in the service, is the lazy man's method of making out requisitions for supplies for general purposes. Catalogues are too often resorted to, when the whole gamut of sizes is copied off and the quantities guessed at, often the same quantity being asked for, for each size, from the extreme of smallness to the largest; this done with the feeling that it would be too long a job to calculate the proper proportions for the kind of work in hand and that, after all, there will be a certainty of having the proper size when it is wanted. We would hardly buy in this way if we were partners running our own shop. It would not then seem too long and tedious to ascertain the relative proportion in which we used material. Not long ago a general storekeeper received from a yard department a request to carry in stock, under the naval supply fund, certain kinds of bolts and nuts. The quantities asked for were not exactly the same for each size, there being a tapering towards the two extremes. But that tapering was done in the office of the yard department, from no data from the shop. The general storekeeper, after a little investigation, learned that sixty times more of a certain size than other sizes quite near it on the list were used in the actual work of the department. The variation in the quantities asked for had no proportion to the quantities used in the work in hand.

We have been learning all the time, and do not forget, it is hoped. The stumbles we have made should scarcely be spoken of, except where useful in making points, when it is recalled what has been accomplished under most disadvantageous circumstances. The general stores system was established in the year that saw the first ship of our new steel navy commissioned. In the score of years that have passed, the change in the fleet has been so stupendous that it makes one blink his mental eyes when he turns quickly to the subject from some other thought. But, comparatively speaking, we of the supplies department have had no such improvement in facilities for meeting this new condition. We have floundered along, wrestling with the questions of ancient and inadequate storehouses, lack of clerical and other help, jumbled methods, jealousy, contempt, envy, and malice, from our professional brothers, improving here and there, tossing old methods on the dump and creating sound structures within our own lines. To-day, the position we find ourselves in is creditable

to the supplies department of the navy. But this means creditable under the circumstances hindering us. There is yet an urgent duty of creative and repair work before us. So up on deck, all hands! And may the master-at-arms give the last one up a good, sound caning on his lazy legs.

CONCERNING THE LAW AND REGULATIONS MAKING SUPPLIES COMMON PROPERTY AMONG THE BUREAUS.

Congress, on June 30, 1890, made the following law:

"All supplies purchased with moneys appropriated for the naval service shall be deemed to be purchased for the navy *and not for any bureau thereof,* and these supplies shall be arranged, classified, *consolidated,* and catalogued, and issued for consumption and use under such regulations as the Secretary may prescribe, *without regard to the bureau for which they were purchased.*" (The writer's italics.)

Congress, groping around in the dark for some scheme for preventing overstocking and the useless expenditure of balances of appropriations, towards the end of a fiscal year, unconsciously, with this law, helped to clear the way towards the only possible *general* stores system,—the one established upon a naval supply fund. But Congress did not achieve its real object with this law, because it was what might be called an impossible law. It directed that there should be a real general store, with all the stock therein common property, but it left the annual allotment of money, with which to keep stocked up, still divided among six navy department bureaus.

Just one little illustration (dozens could be given if it were thought necessary) to show the chaos that this law would have brought about if administered as Congress must have intended. One bureau might have millions to spend for supplies while another was alloted but thousands. The smaller bureau, as it were, knows that the larger bureau is obliged to use constantly in its work all varieties of brass screws. The smaller bureau uses a good many of these, too. Therefore, desiring to save its money for the purchase of articles not so common in their uses among the bureaus, it makes no purchase requisitions for brass screws, but, instead, helps itself whenever its wealthy and powerful friend puts a new lot on the *general* storehouse shelves. It is thought this example is sufficient to make the point.

The Department saw this at once, it is presumed, and letting its blind eye cover the last words of the law, "without regard to the bureau for which purchased," read the words directly ahead, "and issued for consumption or use under such regulations as the Secretary may prescribe," as permitting it to brace up the law in a way that would at least allow it to be put in operation to a degree. And so is was "regulated" as follows:

"All supplies purchased during a current fiscal year shall be kept separate from other supplies, and be held by the general storekeeper for consumption in the department for whose use they were intended when purchased. * * * all such supplies remaining on hand at the close of any year shall thereafter be subject to requisitions of departments without regard to the bureau for which purchased."

And even with this regulation the law has not worked,—that is, in the direction Congress intended. For the bureaus have asked for just as much money, comparatively speaking, and have turned in no balances, of amount, at the end of the fiscal years.

This regulated law has created a general stores system that makes the student in the science of government storekeeping, who by chance is a humorist, laugh, and he of a serious mind, weep in despair. It is as prodigal in the expense of its necessary administration as the New York Yacht Club is with the beautiful printed matter circulated among its members.

The best system for a *general* store is that which will provide at the time needed the necessary quantity of supplies of the proper quality at the lowest possible price. In "price" is included not only the charge made for the articles by the contractors furnishing them, but all the expense of administration. Under these conditions, the naval supply fund method of keeping store comes very much nearer perfection than that one in which the bureau appropriations form the capital.

So long as supplies, that may be used by more than one bureau, are purchased directly under bureau appropriations from the commercial world, laws and regulated laws will not prevent the officers who represent the bureaus under whose appropriations they were purchased from looking upon them for all time as *their* stores, and this sense of ownership affects injuriously, under existing regulations, efforts towards economical administration of navy yard affairs. Take an example of some common article. Say

spruce lumber. The naval constructor buys 40,000 feet. After the following first day of July there is left in stock the amount of 30,000 feet. The civil engineer presents to the general storekeeper a stub requisition for 10,000 feet of it. The naval constructor hasn't a leg to stand on, under the letter or the spirit of the law and regulations, in preventing its issue. It is not special stock in any sense of the word, and if it were possible that spruce would be needed in an emergency, it could be bought almost as quickly as a pound of sugar at the corner grocery. The general storekeeper can not help the naval constructor out, even if disposed. The civil engineer gets the lumber. Then friction starts anew. Although he may know nothing about the case, the constructor begins talking about the civil engineer holding up the yards and docks job until after July 1st, in order to get hold of *his* spruce. He also says he doesn't know how he found out there was so much spruce, and that he suspects the general storekeeper of having gone out of his way to tell him; that it is quite wrong, anyway, that the general storekeeper, only a *paymaster*, should have the say about the issue of *his* lumber. Passing the civil engineer the next day, it is strictly a military ceremony that takes place; and in the meantime he starts in despatching to the general storekeeper frigid, peremptory notes, calling his attention to the careless manner in which the storemen handle construction stock in store, or other lapses. And so comes friction, that damning and expensive influence that so enters into official life. If the spruce had been carried under naval supply fund, there would have been a clear sky from the time it ceased to be a tree to the time it became a handsome but frail new sidewalk in a modern yard.

As the Department read with a blind eye parts of the law of Congress, the Department's employes have read very often many parts of the regulated law with a hopelessly blind eye. A general storekeeper administering this regulated law for the best interests of the government could be court martialed, at any time convenient to the Department when it was short of work in that line, for violating it. Of course, if the Department ever took such a step in the case of a conscientious, hard-working storekeeper, it would be but common justice to give him company, by also trying his friends and enemies, the other heads of departments at the yard. If the general storekeeper threw open his doors on the first of each July to all comers, there would always be one or

two yards departments that would not have to buy much for several months, from their own appropriations, while there would be other departments that would, in a week or so after the first of July, have to stop certain work in which the fleet would be vitally interested, waiting while they bought more stock to finish the jobs. Remember, the wealthy departments would not have advance information from their poor friends as to what kind and amount of their stock were to be swooped down upon on July 1st. So they would be unable to submit any advance purchase requisitions to meet the great July robbery.

But while the earnest general storekeeper has been violating regulations, for the best interests of the service, as a whole, the other heads of departments at the yard have been violating regulations for the best interests of only the bureau they represent. And here comes up one of the most damning points of the system under the regulated law. All sorts of devices and subterfuges are resorted to by them in order to protect their stock from their brother vandals. Some do it secretly, with a "shoo" of silence upon their lips to their subordinate accomplices, while others, with a healthy, deep-sea affrontery, make no bones over the matter. Once upon a time the head of an important department at a navy yard bitterly complained to the commandant of the fact that he was obliged, towards the end of each fiscal year, in order to save his stock in the general storekeeper's charge, to draw it from store in large quantities, not really needed for specific jobs, and store it in the buildings in his charge. And yet the last words of the regulated law, in the regulation book on the desk of that officer read, "and in no case shall supplies be drawn from store except on requisitions to fill specific job orders." Every one knows what the spirit of that regulation calls for.

Knowing that a general storekeeper, who really respects himself more than he does portions of the regulated law under discussion, would not let a yard department take out of store supplies that had been purchased by another department for an expressed object of work, let us say a ship under repairs, heads of departments, in submitting purchase requisitions for supplies, often make the "object" the repairs on more than one ship. For example, take a lot of commercial steel bought in May for repairs to the *Fly* and the *Bat*. When July comes the general storekeeper will not allow any other department to touch the steel, as both

vessels are still under repairs. The work on the *Fly* is completed and the ship is commissioned July 15, but the work on the *Bat*, which is a navy yard "steady," drags along for two years longer, and the steel is held exempt all that time. In the meantime, the department buying it has used about two-thirds of it for purposes other than repairs to the two ships named, while other departments in the yard have not been allowed to draw any of it. All this time the current appropriation of the bureau concerned has not had to be taxed for the purchase of common commercial steel for its department at the yard in question. Much better, says the zealous and wide-awake head of the department, who engineered this matter, than letting that uncivil engineer across the street have all "my" steel. Yes, Mr. Zealous, you have protected your bureau all right, while the general storekeeper was trying to protect the best interests of the service and Congress was trying to protect the government, but what a mess of inefficiency and useless expense it all makes.

Another head of department, and he be indeed a man of genius, requires a lot of sheet brass for manufacturing articles of ship's equipage. His purchase requisition for it requires the contractor to deliver it cut up in special slips or sizes, as needed for the articles into whose making it is to enter. This costs more in the end than buying the same brass in commercial sizes and cutting it up in the yard as wanted. If, after the first of July, the others come around for his brass in the general store, he tells the general storekeeper, or the commandant, in case the former is not friendly, that the brass has been specially cut up at an expense, and on account of the peculiar sizes, is specially adapted for making so and so. The stock is reserved, and perhaps some of those peculiar sizes remain in the storehouse for ten years.

Once upon another time a navy yard department drew from store on June 28th an immense supply, comparatively speaking, of a certain article it had purchased during the year. The "object" stated on the stub requisition drawing it from store was, "care of ships in ordinary." The general storekeeper returned the stub requisition inviting attention to the fact that there were no ships in ordinary at the yard at that time. Of course the general storekeeper knew that the stub requisition was being used simply as the means of transferring this big stock from the general store to the private, illegitimate store of the yard department, so that

no one else could get hold of it after June 30th. Well, the yard department regretted the *clerical* error and changed the "object" on the stub requisition to "for repairs" on two vessels that had not yet reached the yard, and on which no surveys had been held, and for which it would have been impossible, therefore, to have opened an honest job order.

A strange device reported to have been resorted to at times to circumvent the regulated law, but entirely different in character from those just mentioned, is agreement between heads of departments not to touch each others stock, no matter how long it remains in store. Of course, such agreements have to be limited to the tour of duty of those entering into them. But this method can not be entirely effective, because there are always one or more yard departments who could never be got to make such a compact, for the reason that they have little to lose by the full operation of the law and much to gain.

And so it goes. There is no use taking up space and time by giving more examples. The tricks, and they certainly are tricks, are various and numerous and being resorted to all the time. The humorous general storekeeper laughs, and he of the sorrowful mien weeps.

Let us pass now to some important special subjects, connected with the everyday work of storekeeping, which need discussion.

KEEPING UP THE STOCK.

While the care of the stock in store, and the proper accounting for it, are most important duties, of the supplies department, that should never be neglected, all that the customers, the yard departments and the ships in commission, interest themselves in is having their supplies in the quantity and at the time necessary.

These requirements should be paramount *at all times*. Whenever there is no supply of an item to meet the demand a black mark is recorded against the general stores *system*, and properly so, because the yard departments and the ships can not be expected to bother over determining whether or no it is the fault of an individual, and not really the system. When stock becomes exhausted, time should not be wasted in explanations as to the cause. Instead, the mental powers of the administration should be concentrated in determined effort to have no recurrence of the lapse. Ingenuity should be invoked towards discounting "emer-

gencies." Of course, in spite of all human effort, there will be times when there will be no supply to meet demand for certain items, but these times should be reduced to genuine emergencies, where all the foresight in the world would have been useless.

To meet these all important requirements, it is necessary that the officers of the supply department take personal part in the work connected with keeping the stock up; not be content with saying do this, or that, or asking is this or that done, but help do things. Why should not *officers* have actual, active work in the details of this, their most important duty connected with storekeeping? Any one can sit at a mahogany desk and sign his name to invoices, bills of lading, letters written by someone else, requisitions, etc., but it is not every man who can keep the stock in a great navy storehouse in a manner that, on the whole, satisfies his customers—the yard departments and the ships. That may require genius at times. We may have the best ships and perfection of discipline and esprit with the personnel, but when the battle comes and we do not know how to shoot, we will not be able to " deliver the goods " as the country expects. At our storehouses, if we deliver supplies in the quantity and at the time needed, the supplies department will have delivered the goods as the navy expects. But general failure, at this time of battle for us, would make our storehouse plant, with its studied organization, a government folly.

A few words about the practical steps in keeping stocked up. As referred to in the white lead example (page 6), a low " limit " should be established for each item carried in stock. There is a question as to what this limit ought to be. Experience has shown the writer that, on an average, a six months issue of an item is a wise limit. There are many items where a four months' issue is a safe limit, and yet there are others, especially in the case of steel and iron material, where a year's issue is not too safe. It takes a long time to buy even the commonest kind of commercial articles under the present purchase system, and in fixing the limit, a possible rejection, and consequent replacement, must also be provided against; and after these calculations are made, a wide margin of safety arbitrarily added on.

After the limits have been established, through research and calculation, the task is not ended. The limits should always be watched, and when stock runs low, or becomes exhausted before

new delivery, new calculation should be made with a view to increasing the limit. It is a good storehouse rule to require the stock tally card and also the stock ledger sheet placed on the general storekeeper's desk whenever an item of stock becomes exhausted. This will work great benefit where the general storekeeper, in every case, conducts a personal investigation, with a view to changing the limit, if necessary. The writer knows of but one general storehouse where this rule is in effect. There it works in the most admirable manner for efficiency, and is considered the only means by which the general storekeeper can keep in proper touch with the most important part of his business.

The established limits should not only be written on the stock tally cards, as guides to the storemen, but also on the stock ledger sheets, so that the bookkeepers may act as a check, to some extent, on the storemen who post the tally cards. It might be well to explain here, for the benefit of some readers, that a stock tally card is a pasteboard slip kept *with* the item of stock it covers. On it are entered, in pencil, all the amounts of the item received or expended, a balance being struck after each entry; the last balance on a card always showing, therefore, the amount actually on hand in the storehouse. No prices are entered on the card. On the bottom of each card is written the limit of the item it represents. The stock ledger sheet (loose leaf book system) is the ledger account of quantity and value, showing all receipts and expenditures in detail. It is kept by the bookkeepers, in the office, away from the stores.

The limits should be made liberal enough to permit the limiting of requests on the Bureau of Supplies and Accounts for new stock to one each month. It is doubtful whether the Bureau could properly handle the business were requests sent in oftener from the navy yards. As balances reach the limits on the tally cards during the month, the fact should be reported, by the storeman who strikes the last balance on the card, to the head storeman. When the time arrives for the preparation of the monthly request on the Bureau of Supplies and Accounts, every tally card should be gone over by the storemen, as a check on the reports made during the month. The quantities to be asked for on the request can only be determined after careful study, and in this work the general storekeeper should again have a personal hand. In the cases of hundreds of articles, where the commercial supply

always promptly meets demand, a six months' supply is sufficient to ask for. There are other articles of which, in order to obtain the benefit of the lowest price, it is well to buy more than a six months' stock at a time. At one yard the practice of calling for an eight months' supply of most of the articles carried under the naval supply fund has been found to work well. There are a few articles that turn over so quickly and are so easily purchased, at little risk of rejection after delivery, that a three or four months' supply is sufficient to ask for. But as a general economic rule, the quantities on a request should not be below a six months' supply.

With the all embracing naval supply fund, under discussion, a reserve supply of certain very important articles, to be kept in stock against the emergency of sudden hostilities, could be managed within the fund. When the Department issues an order in a specific case, simply purchase the amount to be reserved, put it with the rest of the stock of the same item, and increase the ordinary limit on the stock tally card by the amount of the reserved stock.

DELIVERIES OF SUPPLIES, BY CONTRACTORS, AT THE YARD.

This matter is in a state of confusion, which has continued for a long time. There is no reason for its continuance; a simple direction from the Department would set things right.

Some years ago, when there were few or no facilities for running railway cars into the navy yards, contracts generally called for the delivery of purchased supplies at such place in the navy yard as the commandant might direct. That "place" was *always* indefinite, most contractors not knowing where it was until their wagons finished a weary beating from building to building. The writer recalls a case where the "place" was declared to be the floor of a gallery running around a room on the third floor of a storehouse. With the establishing of railway terminals in most of the yards, a new style of delivery was introduced, and, although "Where the commandant may direct" is not entirely gone from us, we now have "Delivered *alongside* cars placed in the navy yard." That is, the contractor delivering supplies by rail, must unload the cars in the yard. This is one of the strangest pieces of business the navy has ever been guilty of. A merchant in Omaha contracts to deliver supplies at an eastern yard. He ships

them consigned to the general storekeeper of the yard. The car is run into the yard, and the merchant way out in Omaha must arrange with some firm of freight handlers in the east to go into the yard and take the goods off the car, although the railway track may run along the delivery door of the building in which the goods are to be stored. It would seldom cost the government more to take the articles, delivered by a contractor, from the car and place them in the building where they belonged than to pick them up from alongside the car. But be it more or less expense, it does not matter, for the government would get back what is paid out in handling, by the lower prices bid by merchants, when they realized that this most unbusinesslike practice of the navy was done away with.

Readers not closely connected with this work may think imagination is playing a part here. But these are stern facts. It is believed general storekeepers now do not always insist on the pound of flesh, and unload many cars put in the yards; but in doing so they render themselves liable to be called to account, for the wording of the contracts is plain.

Many examples from life could be given of the bad results to both government and the merchants of this wretched method of managing deliveries, but it is hard work to keep this paper from being so long and prosy that but a very few will read it. So the writer, in order to make his point clear, will give one example, but only one, and that will be the last marked case of the hundreds that have passed under his eye. One morning recently, he watched private teams trudging up a navy yard street bearing galvanized iron pipe from a car at a freight station a stone's throw beyond the boundaries of the yard. The pipe was placed on the ground outside the door of the building where it was to be stored. The car was not run into the yard, for then the contractors would not only have had to pay the teamsters for discharging the car but also the railway company's switching charges. A track ran within three feet of the door where the pipe was dumped. If the car had been run to this place, it would have been easier and cheaper for the general storekeeper's men to have passed the pipe directly from the car to the racks that filled the building, than to pick it from the ground and store it. But the contractor had done his full duty, and, without the knowledge of the general storekeeper, had corresponded with local teamsters,

always on the lookout for such business, and made arrangements for this queer delivery called for in the bond.

On every printed schedule of supplies advertised for, in every contract, and in every open purchase order, there should appear something like the following:

"Deliveries at navy yards or stations must be made as follows, without expense to the government. If by truck, the articles will be delivered in the proper building of the yard, in such a manner that the doors of the receiving entrance may afterwards be closed. If by railway car, delivery will be considered complete by the placing of the loaded car in the yard. If by water, delivery will consist of placing the articles on the yard at the berth assigned to the carrying vessel."

INSPECTION OF PURCHASED SUPPLIES.

The proper inspection of supplies, upon their delivery by the contractors, is an important factor in efficient and economical storekeeping. The navy yard board of inspection, as administered at present, makes a useless expense in our organization. This board, consisting of three officers, is supposed to pass on all deliveries; but it doesn't. What does it do? Why, the members sign their names to the inspection calls, which are the authority of the general storekeeper for taking the supplies into store and paying the contractors for them. Why do these members generally only sign their names? That is another story, too long to tell this time.*

This much should be stated here: it is all important that some method be adopted at once by which it will be known by record, who actually make the inspections, for it is taken for granted that in every case some person looks at the supplies before the call is signed by the three members of the board. It is useless saying, "You have a Board of Inspection. Hold its members responsible," or, "You have the head of such and such department. Hold him responsible," because, practically, you can not do it. And this, after all, is a very practical question. When supplies, after being passed and paid for, are found at variance with specifications, the general storekeeper wants to know who the person was who stood up before, and in sight of the supplies, and declared them to be according to the specifications under which they were purchased.

* See "The Purchase System of the Navy," by Pay Inspector Mudd, No. 117, page 108, PROCEEDINGS U. S. NAVAL INSTITUTE, March, 1906.—EDITOR.

Not long ago the general storekeeper at one of our northern yards discovered that some pipe fittings of ordinary weight had been passed into store and paid for, where *extra heavy* fittings had been called for by the specifications, plainly typed on the inspection call. He knew none of the three officers who signed the call had seen the fittings, except in the case of one, perhaps, who saw them in order to count them, not as an expert. He knew the head of the department that made the inspection had not seen them. He tried to learn who made the inspection. The Master Something was looked to by the head of department; but didn't. It was allowed that it might have been Hiram who did the inspecting, and someone else reckoned it was Rube who went down to the store that day. The department concerned, with Solomonian wisdom, sent in a stub requisition at once for the fittings, and they passed out of store as "extra heavy." The general storekeeper was busy at that time and had to neglect something; so he neglected raising a row over this drop in the bucket. The majesty of his "books" had been upheld.

Again, some alligator wrenches were delivered under contract and passed. The specifications called for a large size, No. 4, but the general storekeeper afterwards discovered that he had a lot of the smallest size, No. 1, on hand. No one remembered who had "looked at them."

And again, and lastly, an electrical mechanic was discovered, once upon a time, inspecting a large delivery of officers' mess table ware. Now, if any of those plates or glasses had afterwards been found to be defective, who would have thought of looking in the electrical world of the yard for the inspector?

There ought to be an official record of those who actually do the inspecting under the calls. This could be kept by the receiving clerks in the general store, who hold the supplies until inspected. A certain general storekeeper would have opened such a book long ago had he not feared the board of inspection would misunderstand his action. Even the king of a retrograde monarchy can be proud and sensitive, and insist on being considered as much of a great and good friend as the rest of the gang.

Before leaving this important subject, so lightly touched upon, it will be well to mention a practice that is prevalent to a certain degree, mostly on account of the majority of inspections being made by workmen and others, not officers in the navy. That is,

inspecting and passing according to the ideas of the inspector on the subject, and not necessarily according to the specifications. A common sense latitude must always be allowed in the case of small and unimportant differences. But the waiving by the inspector of parts of specifications, or neglect to ascertain whether the requirements of certain intricate parts of specifications have been followed by the contractors, is to be soundly condemned, as dangerous to the government's interests, and most unfair to the merchants competing. Specifications are prepared after much research and trouble by the bureaus of the Department, and they are seldom the work of but one mind, and it is not for any individual, afterwards, to set his opinion up against them, in the actual work of deciding whether supplies are to be passed or not.

STANDARD SPECIFICATIONS.

The navy has done well with standard specifications, but there is much of this slow and tedious work to do yet, involving much communication between the bureaus. But the good men and the proper men should keep at it. Clear, well thought-out specifications are much more valuable than standard samples. It should be borne in mind in preparing specifications that the navy does not always need the highest grade, the most expensive kind of a certain article. There is too free a use of the term "the best quality." Uncle Sam wants to save money as well as the rest.

Recently a remarkably wise change was made in the standard specifications for an important and much used article—wrought-iron pipe. For years the navy had been suffering under specifications that insisted on having something that, in ninety per cent of the cases arising, it did not need, and which in every case the merchants did not want to give, and in many, could not. Fights and delays innumerable fill the history of this peaceful and ordinary article of commerce. There is one record where it took over a year from date of requisition to obtain delivery of an order. There is another instance where, after advertisement for three weeks over the broad land, the lowest bid for this standard specifications pipe was twice what the kind of pipe really wanted could be bought for at retail. There is also an instance in this history of wrought-iron pipe, as treated in the United States Navy, brought down to the good year 1906, where a well-intentioned merchant who blindly, or otherwise, entered into a contract to

furnish some of the pipe under the navy specifications, had the mills of the whole country closed to him, every iron master telling him that he did not want to bother, where he had to guarantee a percentage of elongation never called for in commercial life. Finally, during one of the merry little squabbles over pipe, when the best literary talent of several bureaus was busily turning out endorsements, someone asked why, when in ninety per cent of the cases all the navy wanted was the best and strongest quality of commercial pipe on the market, there were not two kinds of standard specifications, one for the superpipe and the other for just pipe. That question accomplished the desired result, and there are now two sets of specifications. Is it necessary for the writer to point out the things that were done by that stroke, and some other things? Very likely not. There may be dozens of such cases connected with standard specifications awaiting action. This little example is given to emphasize the need of continued work, but it might be read with certain other portions of the paper, to illustrate.

SHIPMENTS.

The shipping of supplies over the United States, and the rest of the world, is one of the important parts of the work done at a general store. It is fairly well managed at present; but there is room for improvement. One of the changes for the better, that have been made, occurred recently, when the Bureau of Supplies and Accounts was victorious in a long fight to have but one freight appropriation to cover the cost of all shipments made. The conditions that had existed for years, up to the time of this change, were fantastic in the extreme—something like the general stores system without a naval supply fund. The Bureau of Supplies and Accounts alone could authorize a shipment, and yet its cost had to be borne from the appropriation of the bureau having cognizance of the articles shipped. As the Bureau of Supplies and Accounts could not take a step, involving an expenditure from another bureau's appropriation, without the consent of the bureau concerned, a truly opera bouffe situation existed, to again make the humorous laugh, and they of the sober mien, weep. When shipments were made, there had to be a separate bill of lading for each bureau's goods, thus entailing unnecessary expense to the government, not only in freight charges, but in cost of clerical labor and stationery. Often, in making shipment abroad, to one of

our ships, there would be five separate sets of bills of lading, where one should have sufficed. We added to the gaiety of nations, and were the laughing stock of railway and steamship men, although they profited somewhat from our official foolishness. Yet it took years to bring about the change, some in the Department fighting it as if they were taking the last stand between freedom and perpetual servitude. But we are there at last. This is mentioned now, only as bearing closely in style on the important change in regard to the naval supply fund recommended in this paper.

With the one appropriation, styled "Freight," the reform was not complete, one little thorn being left to prick quite often. Charges for shipments made by express were left to be paid for from the appropriations of the bureaus concerned. Why? The writer does not know. Recently, a general storekeeper had on his desk an order from a certain bureau not to incur any expense on account of express shipments of supplies under its cognizance, without its specific permission in each case; another paper from the head of a yard department cautioning the general storekeeper not to make a certain shipment by express, for the reason that a letter had been received from the bureau he represented directing that no liability against its contingent appropriation (from which express charges were payable) should be incurred without its sanction; and a third paper, from the Bureau of Supplies and Accounts, the sole director of shipments, authorizing the general storekeeper to send shipments by express whenever he deemed it expedient to do so, without previous reference for permission. The appropriation acts could easily be so worded as to permit the bureaus to still use their own appropriations for paying express charges on books, papers, and packages, not coming under the Bureau of Supplies and Accounts shipping authority, and at the same time have express charges on supplies shipped under the direction of the Bureau of Supplies and Accounts paid from the general appropriation, freight.

The general storekeeper should be ever on the alert to get the lowest rates in making shipments, taking advantage of all the customs of getting lump rates on mixed goods, car load rates, short haul competition, water carriage, etc. A neat sum of money can be saved to the government in the year by close attention to this matter. And freight bills rendered for settlement should undergo intelligent examination as to classification and rates, before

public bills covering are prepared. At times there is a tendency to take it for granted that the rich and generous railway and steamship companies will not take advantage of Uncle Sam.

As before stated, navy freight is moved under specific orders by the Bureau of Supplies and Accounts. But those documents are too often of the nature of permissions instead of orders. They should always be orders in the strictest sense, and if, upon the receipt of one by the general storekeeper, it is found impossible to obey it in full or in part, the Bureau should be notified *at once.* In no other way can the matter be handled with the business-like celerity that the interests involved generally demand. There is damaging slackness now in this regard, and the immediate tautening of the lines is demanded for efficiency's sake. If it is considered necessary to have a general permission at a yard to make shipments from time to time, over an indefinite period, of an article, when ready in the required quantities, grant permission in the form of a letter, and cover each shipment as made (to satisfy the requirements of the Treasury Department) by an open contract requisition, or, as suggested to the writer lately, by a form of shipment order issued by the general storekeeper in the name of the Bureau of Supplies and Accounts, as transportation requests are now issued in the name of the Bureau of Navigation.

One of the large yards is, to an extent, a supply depot for some of the smaller yards, so far as naval supply fund stores are concerned. When a naval supply fund request is received at the Bureau of Supplies and Accounts from one of the small yards, certain items generally carried at the supply yard are checked off, to constitute a shipment order. The remaining items are advertised. The Bureau not having a detailed stock list at hand, can not always select accurately the items to be shipped from the supply yard. In nearly every shipment order of size thus received at the supply yard, there are a number, sometimes a large number, of items that are not on hand, some even being items that are not habitually carried in naval supply fund stock at the supply yard. The proper proceeding is an immediate reply by the general storekeeper of the supply yard to the Bureau's order, informing it that in respect to certain named items, the *order* can not be obeyed; and then, for the Bureau to advertise those items at once. But such is far from the practice.

There is a case on record where a general storekeeper sent in

a request in December for some naval supply fund stock. He promptly received notice that certain items of the request would be shipped from the big supply yard. Time went on, and brought some of the articles, but in the May following, beyond the time that it would have taken to purchase under advertisement and formal contract, there were many important items not yet received under the shipment order. An inquiry was sent to the supply yard. Answer came that the items still due would be shipped as soon as received into store. In the last days of August, eight months after the request had been forwarded, the general storekeeper of the smaller yard received official notice that the items still due, twenty-five in number, from the supply yard, would not be furnished, for the reason that *they were not carried in naval supply fund stock at that yard, and that if he still wanted them he should require for them again on his next monthly request.* Wrong! No general storekeeper can successfully keep up the naval supply fund stock with the uncertainty that this practice creates. This work should be carried on with the certainty and uniformity of the swinging pendulum.

A general storekeeper, once upon a time, made a naval supply fund request for 2,000 gallons of oil for ships' engines. He received word it would be supplied from another yard. *One year after* he had sent in his request he received the first consignment, 1,000 gallons. He has not yet received the remainder. Several inquiries were made of the supply yard, and each time word came back that there had been repeated rejections of deliveries, but that likely some would be shipped soon. In the meantime, at the smaller yard, oil was being purchased under yard department requisitions. Can anyone imagine that the officers of that small yard will ever again depend upon naval supply fund for lubricating oil? So comes a little loss of respect for the best system of *general* storekeeping that can be devised with the present day facilities. When the general storekeeper of the supply yard received the shipment order for the oil he should *immediately* have informed the Bureau of Supplies and Accounts that it was not in stock, or in stock to spare, and the bureau then should have advertised it, for delivery at the yard requiring it. Articles due to come in at the supply yards under contract should not be mortgaged by shipment orders for the smaller yards. What is the use of always being behind? If articles are not actually in stock at

a supply yard, at a time the smaller yard sends in a request for them, they should be advertised for delivery at the yard requiring them, and the incoming supplies at the supply yard kept to meet future demands.

This weak point is dwelt upon for the reason that it indicates a disease that must be eradicated before it spreads and actually takes the life from the system. Invoices may be delayed and officers of ships may growl. That is bad, but not at all dangerous to the life of a naval general storekeeping system. But administer the system in such a way that no general storekeeper can maintain his stock of general stores, even after the keenest foresight and painstaking calculation, and we are at the beginning of the end, just as the little thread of water sneaking in through the massive Dutch dyke, may be the beginning of mighty destruction. Let us, without delay, dam this fault.

SURVEYS.

About seven years ago many changes for the better were made in the regulations concerning surveys on material and supplies. But there is still room for improvement in this irksome work connected with the supplies department.

At present, if a tin dish pan is worn out on a ship lying at a navy yard, the head of department concerned, on board the ship, asks for a survey, and the commandant has the pan formally examined and reported upon by a survey officer. If it is worthless it is turned into store at the yard. The general storekeeper gets it in a few days, and he then asks for a second survey. Again the commandant has that tin pan formally examined and reported on, likely by the officer who made the first report. The recommendation now is that it be thrown on the dump, where it duly lands, after a few more stiff formalities. A slight change in the regulations would do away with this nonsense, make more little bits of economy, and further efficiency.

One of the most unwieldly pieces of survey work is that on the outfit turned into store from a ship placed out of commission. Under the regulations every item of the hundreds turned in, by the five departments on board, must be surveyed. This involves the issue of volumes, by the general storekeeper, written out on the bulky survey forms, three volumes (triplicate calls being required) for each department, making fifteen books in all for each

ship placed out of commission. The entries required to be made in the numerous columns of these survey forms run easily into thousands,—tens of thousands. Think of the clerical work alone! It was recently suggested to the writer that the regulations be amended, so that the general storekeeper would have to call survey only on articles he deems unfit to go back into active stock for issue. The idea is in the right direction, and could be applied partly, as suggested, but, as a whole, it goes too far. While the general storekeeper would be a safe judge, ordinarily, as to whether articles of "supplies" so turned into store were fit or not, for active stock, it would not do to intrust him with the deciding power in the case of many technical articles of "equipage." A reform along the lines of the suggestion would be to change the regulations so that after the outfit of a ship placed out of commission was received into store, the general storekeeper would furnish each head of department concerned with one of the copies of the ship's invoice of stores coming under his cognizance; these invoices then to be placed in the hands of competent persons, who would examine the articles covered and check off the items that are fit to be returned to active stock. The general storekeeper, upon receiving back the invoices, would request a survey only on the items not checked. This reform is urged.

Another point, small, but important on account of its exposition of neglect in small matters, which bunched together, mean much waste of public money. The official form upon which surveys are requested by the general storekeeper, is 2 feet by 1½ feet in dimensions—rather a massive piece of paper. The quality of the paper used is expensive, being heavy and strong on account of the handling a survey request is bound to get. We have had this form, and no other, in use for years. There is room on one sheet for 38 one-line items. The writer finds that for twelve months recently, at one of our yards, of the total number of survey requests made, 66 per cent did not occupy a half page of one sheet, and of this 66 per cent, two-thirds were not more than four lines. And yet in each case, three of these ponderous forms, 24 inches by 18 inches, were used in making the request. We should have a form not larger than half the size of the present blank. Those who have much to do with survey work will appreciate that this bad point is not too insignificant for mention.

BOOKS, RECORDS, AND RETURNS.

The bookkeeping and accounting in a general storekeeper's office are simple affairs, in spite of what may generally be thought. There are tally cards, of quantities, kept with the stock; stock ledgers, showing quantities and values, kept by the bookkeepers; a book of receipts, showing *total* value of each invoice of stores, from whatever source; a book of expenditures, showing total values only; and a quarterly balance statement, a compact return of the value of the supplies on hand, made to the Bureau of Supplies and Accounts, and compiled from the books of receipts and expenditures. Accompanying the balance sheet, just mentioned, are vouchers, amounting in the aggregate to the total amount shown on the return as having been received and expended during the quarter covered. At the same time, an important statement is rendered to the bureau showing the object of the expenditures during the quarter. Then there are numerous, yet simple records concerning the business of contracts, open market purchases, shipments, ships' requisitions, etc. But all of this necessitates thousands of papers and a large amount of clerical work.

Aside from the matters specifically mentioned in this paper, the writer is not prepared to criticise adversely any of the important papers or books thus kept. In this direction there has been no handicap or unwise law or regulation, and the methods now in force are the result of the best mental effort on the part of those pay officers who for years have been intimately associated with the general stores work. But in spite of all that has been done in this line by those most skilled, there is not the slightest doubt in the writer's mind that, with some concrete incentive (see page 43), many corners would be rounded off and many short cuts hewn out in the mass of "paper work;" and many times the old hands at this work of construction and repair, would rub their eyes and exclaim, "Why was that not thought of before?" as they read where some $2.50 clerk works his brain beyond where theirs had stopped years before.

INVOICES.

The question of the invoices, covering supplies issued to ships, is one of direct interest to many in the service. There has been growling on this subject. The situation has been gradually im-

proving, however, owing to the establishment of an organization in the clerical work of the general storekeeper's office. It is believed that now there is no delay worth speaking of in forwarding invoices covering supplies that are on the general storekeeper's books at the time of issue. There still remains one old and important cause of delay, that not only has not been eradicated during years of protest, but has scarcely been alleviated; that is the delay of yard departments in furnishing the general storekeeper with manufacture invoices of articles made in the yard, and issued to ships. The questions pertaining to yard shop work, in which the general storekeeper is interested, can not be entered into here. Suffice it to state that there is no excuse for this delay. There is a defined limit to the Bureau of Supplies and Accounts authority here. The Secretary has taken hold of the matter a few times, in individual cases, but to that busy man it was no doubt a dry, if not impossible subject. If the chiefs of the manufacturing bureaus would take an active hand in upholding the regulations on this subject, there would no doubt be improvement almost to the extent of satisfaction. As long as the general storekeeper is without the prices from the manufacturing departments, he can not, except in the cases of common articles of which he always has a supply on hand, furnish the invoices to the ships.

CORRESPONDENCE.

It is believed more correspondence passes through the general storekeeper's office than any other point in a yard, and it is likely the Bureau of Supplies and Accounts leads in this respect at the Department. It is therefore fitting in this article to touch upon some defects in handling correspondence.

There are too many formal slip endorsements. In three-quarters of the cases, an office stamp, with date, placed on the back of a paper would suffice. What is generally wanted is something to show the commanding authority that the letter or order has been received. It is unnecessary to state that the order will be obeyed or that the letter has been read.

There is too much time and material wasted over "sir," "gentlemen," "very respectfully," "have the honor," etc. A request or a statement couched in plain, businesslike English is polite. A spirit of deference should be taken for granted where it is necessary. There was a time, and not so long ago, when, in closing a

letter to a superior officer, we wrote, "I am, sir, very respectfully, your most obedient servant." But we have been traveling along the road of sense in public affairs, and we now, at the longest, write "very respectfully" before our signatures. Let us go further in the elimination of the superfluous.

All public correspondence should be conducted in a uniform manner, with paper of the same quality and printing of the same style, the only difference being the distinguishing name of the executive department and the office of the department. The letter head should show from what office the epistle emanates and to whom it is directed. Immediately after the last word of the typed communication under the letter head should be written the initials of the head of the office or an authorized subordinate, or a small seal punched. Something like the following is suggested:

PUBLIC BUSINESS.		NAVY DEPARTMENT.
To { The Bureau of ....Supplies and Accounts.....	From { The General Storekeeper, Mare Island.	
No. 2671.	Enclosures 1.	Aug. 6, 190 6.

Stub requisition No. 3, for naval supply fund stores, for use in maintenance of the general store, is forwarded herewith, with request for approval. *A. B. C.*

{ Commandant's stamp. }

Another example:

PUBLIC BUSINESS.		NAVY DEPARTMENT.
To { The Commandant, ...Navy Yard, ... Norfolk.	From { The Bureau of Supplies and Accounts, Navy Department, Washington.	
No. { 18212 21567	Enclosures	Aug. 4, 190 6.

Hereafter, in filling in amounts passed or rejected on inspection calls, duplication by carbon paper will be resorted to, to insure the same amounts appearing on all copies of a call. *X. Y. Z.*

Every day the general storekeeper receives letters from merchants that are not signed, the name of the firm being typed in. There is no doubting the genuineness of these documents, and on them most important action, involving dollars and cents, is often taken, with no hesitation whatsoever. At one of our yards the general storekeeper has for some time past had his name and rank typed in at the end of letters to merchants not sent through official channels, in lieu of his signature. He has on office rule that such letters must bear his initial before being press copied. He even contemplates ending such letters with "The General Storekeeper" instead of name, rank, and the designation of general storekeeper. The name and rank of the general storekeeper are of no importance in correspondence with the commercial world.

Much time is wasted in briefing letters on the back. The regulations call for official letters to be folded and endorsed on the back with name of station or ship, date, writer's name and rank, and a brief of the subject. This backing is useless in many of the filing systems in the offices of the naval establishment. Would it not, therefore, be wise to have the briefing done in the office where the letter is filed? Certainly it would be economy in administration, taking the service as a whole. It is noticed that letters emanating from the bureaus of the Department are not backed, although those offices are not exempted by the regulations.

The system of filing letters flat, without folding, is now in use throughout the commercial world. It is also in use in many of the offices in our navy yards. It is only a question of time when it will be adopted for the entire public service. Anyone can appreciate what a time-saving flat filing makes over the method of keeping letters folded and stuffed away in unhandy file boxes.

Much paper is wasted in our correspondence. The regulation letter sheet is 8 inches by 10½ inches. The general storekeeper at one yard has for over a year been using in his direct correspondence with merchants a letter sheet of half this size, and has found that it answers in ninety per cent of the letters he writes. This abbreviating of letter paper is common among business men, and is most sensible. We could, in addition to the present letter sheet, adopt one two-thirds the length, to be used for short letters. That would admit of one fold of the regulation width.

TRANSPORTATION OF ENLISTED MEN.

The general storekeeper furnishes transportation to enlisted men changing station. This work, involving the disbursement of money, is foreign to his other duties. It is also illegal, as the general storekeeper is not a disbursement officer and makes no return of the money he thus handles. The cash he needs he "borrows" from the paymaster of the yard, and, after a strange interchange, cancellation, and substitution of money receipts, that makes even a paymaster dizzy at times, he pays it back at the end of the month in the form of a public bill for the total amount, made out in favor of the paymaster of the yard. This transportation business, with its paraphernalia of request books, schedules, reports, orders, countermands, etc., should be tranferred to the paymaster of the yard, who has plenty of time to look after it, and who is as accessible as the general storekeeper. The general storekeeper needs all his time and that of his clerks for matters pertaining to supplies.

BUILDINGS FOR THE STORAGE OF SUPPLIES.

Some of the yards are in great need of modern storehouse facilities, especially those at Boston and Norfolk. Money in this direction will be wisely spent. Large sums have been wasted, so far as conditions in sight indicate, during the past ten years, on buildings for the various bureaus, including that of Supplies and Accounts, at useless naval stations, while Norfolk and Boston have been neglected in storehouse matters. And at other yards, where there are modern main buildings, there is lack of outlying storage places, for classes of material that should not be kept in the main buildings. These wants affect perceptibly the efficiency of the supplies department.

THE CIVIL FORCE OF THE GENERAL STORE.

The force of clerks and others connected with the general store at navy yards is apparently sufficient in numbers, but is underpaid. With a few isolated exceptions the highest pay given is $1200 per annum, and there are very few such positions. Two dollars and forty-eight cents per diem is too common, and promotion from that grade does not occur often. We lose many good men each year, after the trouble and expense of educating them, by their passing to positions in other executive departments

of the government that pay more than the Navy Department. This drain of useful material and the entering in its place of the raw, affect in a marked degree the efficiency of the supplies department. It is not only the loss of good and promising men, but it is also the damaging effect of unstability in the offices. There should be a system of increase of pay through length of honorable service. However low the percentage of increase, it would prove an incentive to many to remain, to do good work and behave themselves. Sooner or later, and the sooner the better, we must adopt a system of old age pensions for our civil servants.

Some years ago, the Bureau of Supplies and Accounts, with the approval of the Secretary of the Navy, issued a manual for the use of the employes of the general stores. This, covering, to an extent, a long felt want, was an economical step in administration. But the book, however useful, was the work of but one mind. Although still in constant use at the storehouses, the time has come for its revision, owing to many changes in laws and regulations since its issue, and perhaps, for its enlargement, owing to the fact, as stated before, of its being the work of but one officer. The old book should be put in the hands of experts, and from it should be produced an all-embracing manual to date. The scheme of a printed detailed guide to every step taken in the day's work at a general store, at the elbow of every employe, should not be allowed to die with the passing of the present book. At one of our storehouses the writer has noticed that the edges of every copy of this manual indicate constant reference to its pages. There is no doubt it is useful. Let us make it more so.

Before the publication of the general manual, an experimental one was issued by the general storekeeper's office at the New York navy yard, for use at that yard only. On the front page of the book appear the following words of advice to the civil force:

"Be as honest in the daily measure of work you give the government as you would want to be considered in your private life by those among whom you live; be thorough in all the work you perform, be it small or large in quantity, be it important or not in character, remembering that no excuse should ever be accepted for lack of thoroughness; and, above all things, be resourceful, for a manual could not be written that would cover all the ground that has to be trod during the work days at the general storekeeper's."

These words, if followed strictly by all in the civil service, would give our government the most useful body of public servants in the world. Let us help weak human nature to live up to this exortation, by making certain to the clerks some reward, if they do their full duty, all the time.

PUBLIC SERVICE ECONOMY.

It is poor business on the part of the government cutting down expenses by ignorantly shaving the estimates of its trained officials, thus publicly announcing its unbelief in their statements, and having it understood that there is an established distrust, on the part of the alloting power, of *all* estimates. Close scrutiny always, but not this. Such unwise action sometimes hits the nail on the head, but much oftener causes additional expense. Better that intelligent energy be used in another direction. The writer will take the liberty of hinting at a method, the mention of which will not be inappropriate, as the general stores system of the navy would be certain to profit by its application.

Establish a government system of awards or prizes for improvements resulting in public service economy. Have three grades. First, a grand prize of $1000, to be known as The Grand Prize, U. S. Public Service Economy. This to be awarded for marked improvements in methods of public work of any character, that, if applied, would result in permanent economy, and by which more than one executive department, or bureau or office not connected with an executive department, might benefit. Second, a prize of $200, to be known as Second Prize, U. S. Public Service Economy. This to be awarded for any marked improvement by which but one executive department, or separate bureau or office might benefit, or for an improvement not so marked as warranting a grand prize, but by which more than one executive department or separate bureau or office might benefit. Third, an award of $25, to be known as U. S. Public Service Economy Award. This prize to be given to anyone making an improvement which, in point of importance, would not be placed under the first two classes, but which would result in permanent economy in public work.

The final awarding of these prizes to be made by a national commission, or board, to be composed of persons selected from the public service by the President. So far as the Navy Department

would be concerned, the following is suggested as a plan of the machinery for operating the award scheme. At each navy yard, station, etc., have a permanently organized board of from two to three members, the commandant or senior officer being one, to be known as the Public Service Economy Board, such and such a yard. Anyone in government service at the yard to have the privilege of submitting at any time to the board a suggestion for economy in public work. If, in the opinion of the board, a suggestion would result in permanent economy, if applied, the suggestion to be forwarded to the Secretary of the Navy, with a recommendation as to which prize should be awarded. But before this final action, the papers in the case to be submitted to each head of department at the yard, and to the surgeon and paymaster of the yard and the commanding officer of the marine barracks, for any comment they may choose to make, these comments to form part of the case sent to Washington. If the board forms an unfavorable opinion of a suggestion submitted, it be not sent to the Department, unless the person interested requests it.

At the Navy Department have a permanently organized board of from two to three persons, to be known as the Public Service Economy Board, Navy Department. All suggestions received from yards, etc., after being submitted to each bureau, the judge advocate general, and the commandant of the marine corps for comment, to be reviewed by this board. If suggestion is approved, forward, with all papers, to the Public Service Economy Commission, with a recommendation as to the class of prize to be awarded. If this board of review thinks unfavorably of a suggestion, it be not forwarded to the national commission, unless the person interested requests it. The action of the commission on a suggestion to be final and beyond the power of review.

The names of prize winners to be publicly posted, directly after award is made, at the places where they work; quarterly, in departmental circulars; and annually, in the report of the commission to the President.

All employes of the government, from the President down to the humblest rating, to be eligible for prizes.

In illustration of what detail this scheme of awards would embrace, let us suppose it in operation. A clerk from the general store at a navy yard comes before the yard board with the following statement:

"Here is an official form that I use constantly in sending contractors certain necessary information. You will notice that there is a great deal of printed matter, with blank spaces scattered throughout, to be filled in by typing. It takes me two minutes and a half to type in one of these forms. I have drawn up a new style of form that will convey exactly the same information to the contractors. It takes me two minutes to fill in the new form. I have calculated that 12,000 of these forms are sent out annually from the various general storekeeper's offices. Mine will save one-fifth of the clerical time now put in on the one in use. For example, consider that clerks throughout the service, handling these forms, work with the same speed on the typewriter. A half minute saved on each 12,000 papers would amount in a year to about fifteen clerical days, which at the pay I am receiving, $2.48, is worth to the government $37.20."

The board proceeds to investigate these statements and finds them true; also finds, after the suggestion has been passed through the departments and offices of the yard, that the changes made in the form do not conflict with any laws, regulations or established customs, or with the economy of any office. The award of $25 finally made to the clerk for his improvement is more than balanced by the first years' saving to the government.

Another clerk comes before the board with the following:

"I have here a form for a notice that I send out constantly in my day's work. This notice is not needed and should be abolished, for the reason that the offices to which it is sent already have on hand the same information, only in a different shape."

He then explains in detail. The board investigates and finds everything as stated; and this clerk also receives the honorable award of $25 for having been the means of abolishing a paper that the government has wasted hundreds of clerical hours over for many years, and which had become such a matter of uninteresting routine, that it had drawn no particular thought to it, until our clerk, with the incentive of public honorable notice and a little cash bonus, with which to buy Christmas presents, began to look around to see how he could economize in the work of his desk.

The writer would like to see Congress try this plan. He will prophecy that if allowed to run for two years it would not be abolished.

AN APPEAL.

The writer makes a plea for harmony in the work towards a better general stores system; for all to look at the matter earnestly with a business eye. Each bureau has enough of its own technical work to keep it busy all the time, without trying to hold on to the bartering and storekeeping. When a bureau does this, it is unpatriotic, as it surely increases the expense of running the Department. The human weakness of wanting to appear as the directing power in large purchases,—the seeking for self-aggrandizement before the great people of the commercial world, is perhaps at the bottom of much of this tenacious holding on. To a judge, say the Secretary of the Navy, the insistence of a bureau to do work properly belonging to the Bureau of Supplies and Accounts, or of duplicating the work of that bureau, must mean one of two things; either the Bureau of Supplies and Accounts is not performing its duties as intended by the laws and regulations, or there is not as much reason for the existence of the other bureau as it might claim. Purchasing supplies directly from the commercial world, under the bureau appropriations causes the bureaus to appear more prominently before the merchants than if the supplies were carried under the naval supply fund. This may cause opposition to the reform proposed. But each to his last.

Friction is a great foe to efficiency—to economic administration. A smart officer, with an uncompromising dispositon, in the position of head of department, is often more of a menace to the efficiency of the yard than one much less brilliant but possessing some wisdom, for the former is a breeder of discord; and good work and discord have never occupied the same place at the same time. There should be no fighting without just cause. If there is cause, the fighting should not consist of attacks made in the back, in the privacy of the superior's office, or in a committee room. It should be with the weapon of open assertion, sanctioned, and even compelled by regulation. A healthier spirit would prevail, and there would be little soil where deceit, malice and slander could be cultivated. Under a system of "having it out" in the open the parts where the friction takes place would no longer be hidden from the master machinist, the Secretary of the Navy. He could then go straight to the spot with his tools and fix things,—or people.

If someone would concoct a potion that would cast out greed, malice, envy, and uncharitableness from official life, and put the price of it, say at $6,000,000, Congress would make a better investment in the purchase of it for the navy than by appropriating a similar sum for the monster battleship now being discussed, war or no war. Sometimes, in the turmoil of our doing things or trying to do them, one might, barring the scenery and such, imagine himself transported back to the middle ages of romance, with the swaggering men-at-arms, the sneaking courtiers, the jesters, yea, the hired ruffians, the king, the royal closet, and lastly, the axe and the block. Perhaps a reader will ask, "What are you aiming at? Trying to stop the planets in their course? For you have simply been referring to ordinary human nature as it has existed since man came and will exist 'till man passes." No, the writer has been referring to the human element of the United States Navy, which is the best aggregation of men in the world. The student of philosophy should not apply his ordinary deductions here. The aggregate power within us can place and maintain us, as an organized force, on a plain to which the philosopher would have to make a special ascent.

The writer is not trying to instruct for the pleasure of telling what he knows that others do not. If we had a clearing house of knowledge in the navy very few would be left insolvent—there are not many fools among us. He is only pleading with his brothers to help make things better, and he believes a paper like this will do some good, at least among the earnest men.

Too often our efforts are expended against each other, as in a tug of war; and the navy profits nothing, so far as final results are concerned. Let us trample down some of the greed and forget stale prejudice, and,

> "With a long pull, and a strong pull,
> And a pull *all together*,"

do things for the navy as a whole.

U.

A FEW

By Li

The q
been ask
to this i
particula
true ans
service r
affairs w
tion, " y
The d
will conv
to fight
crystalliz
of vessel
The b
few unq
forth a f
system v
ideas are
believe t
set forth
would-be
who will
The t
enemy's

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

FIRST HONORABLE MENTION.

BATTLE REHEARSALS.

A FEW THOUGHTS ON OUR NEXT STEP IN FLEET-GUNNERY.

"E Pluribus Unum."

By LIEUTENANT-COMMANDER YATES STIRLING, U. S. Navy.

The question "are we training our navy to fight battles?" has been asked frequently by officers of each other and the answers to this inquiry have been "yes" or "no," depending upon the particular officer's degree of optimism. The importance of the *true* answer to this question needs not to be urged. All in the service realize this and some are striving to bring about a state of affairs wherein we can safely say, when we are asked this question, "yes, we are training our navy to fight battles."

The day of single-ship engagements is passed, and our answer will convey with it the meaning that our ships are being trained to fight together; that the training not only perfects the ship but crystallizes the team work which is necessary to fight a number of vessels as a unit.

The belief that this question, if asked to-day, would receive but few unqualified "yeas," has given the writer his impetus to set forth a few ideas, and some remedies, to be applied to our present system which he claims will produce the result sought. These ideas are conclusive in the mind of the writer, but he hesitates to believe that the reader will take his views as axioms unless he can set forth logically the reasons for each. This, to the struggling would-be essayist, is not easy, and he begs the indulgence of those who will wade through his poorly-constructed arguments.

The training of the fleet to fight and win a battle against an enemy's fleet is the object in mind. All training must of neces-

sity lead up to this grand achievement. That most of our present training is in the right direction is conceded without question, but he submits that it stops short of the real objective. Ships are trained to fight their guns singly, and maneuver together. The writer's desire is to combine the two and thereby work our personnel and materiel up to the knowledge and power to do what the country will demand of it in case of war—fight and win a fleet-action.

The unit of the fleet is the ship. With this unit we must begin our training in order that it may be able to perform its duty in the fleet. The most important part of a battleship's training is to fire her guns to hit. The present system is logical and has few, if any, critics. Eventually, it is claimed, our ships will each be given a battle-practice at unknown long ranges, firing all guns during the same time interval. Upon the completion of such a practice, a ship making a high percentage of hits may be considered creditably trained to fight a *single-ship engagement;* but she has not been trained sufficiently to fight in a fleet action.

A simple analogy may be taken of a troupe of all star actors. If they should have the temerity to attempt to produce a difficult play without a single rehearsal, I am sure the public would not forgive them the loss of their money, even if individually they were each excellent actors. And even here the ship has the big end of the analogy, for the actors have at least played before but the ship never has—wars being luckily less frequent than theatricals.

THE VALUE OF REHEARSALS.

Rehearsing a battle is by no means simple. Many minor things must be done before the dress rehearsal is possible. These I have called the small rehearsals, and they will consist in trying out a quick and sure system of signals, and the simple maneuvering of the fleet. After a certain degree of proficiency in the small rehearsals, then the *battle rehearsal* by ships, then by divisions, squadrons, and, finally, by the fleet. The value of a rehearsal in all other games of skill—base-ball, foot-ball, theatricals—the reader will readily acknowledge. Wherein does our game of skill differ from others. By frequent rehearsals, we can so perfect ourselves in our art, that when the day comes to fight we can do it like veterans; each familiar pitfall will be seen in time

and carefully avoided; familiarity with our tools will make our duty run as smoothly as running water, and the interference by the enemy's bursting shell will be minimized, for our minds and hands will work automatically.

THE SMALL REHEARSALS.

Signals.—We all believe that flags will be untrustworthy in battle, then why not discard them for battle signals at once? There are many disadvantages well known in the use of flag signals. The principal ones may be mentioned in passing: The color is misleading on account of the tricks of the sun on bunting; effects of wind, bunting end on is difficult if not impossible to distinguish; fouling, probably the most frequent. All know the impossibility of reading a fouled flag. If we discard flags we must choose shapes, for there is nothing else on the market at present. The shape has a great many advantages which the flag lacks; they may have any color; wind cannot affect them, and they do not foul. They are, however, heavy unless made small, and if small, their usefulness diminishes at distances. A happy mean, however, may be hit upon after the shape is installed in its rightful place. Of course, if we can train ourselves to such a high degree of proficiency, wherein we can maneuver without signals, then the problem is solved. In the writer's opinion this is impossible, foolhardy, and dangerous in the extreme. Returning to shapes, they can be readily hoisted, take up little room, and can be easily read. They may be made so simple in their combinations to form a signal that their meaning may be told at a glance without aid of book or memoranda.

Maneuvering.—The simple maneuvering spoken of above should be similar to the present system, with the one exception: each officer and man should be placed where he will actually be if his ship were in action. If the conning-tower has been built to protect the captain in battle then he should be in it at maneuvers. There should be no one in an exposed place on deck unless his duty in action will require his presence there. If speed cones are to be used in action, which is doubtful, they should be used in maneuvers, otherwise, after a few preliminary drills, the cones should not be used, and the eye alone trusted to tell the speed of consorts. The stadimeter has doubtful use in battle for keeping position, and if its utility is questioned, the best plan is to maneu-

ver without it, trusting to the eye to keep the proper distance. During these preliminary maneuvers for the purpose of getting the personnel accustomed to the new order of things, the men need not be kept at their guns nor the fire-control party at their stations; this drill is primarily for the captain, executive, navigator, and the officers of the deck, not with the idea that the young officers of the deck will be called upon to command their present ship in action, but for the reason that they will eventually be eligible to command a ship and should be given their preliminary training continuously. However, as the commanding officer is the man who must fight his ship in action, he should be the one to maneuver her at these preliminary drills. On account of the inconvenience of the present conning-tower commanding officers may hesitate to maneuver from this location. If so, this should be reported with the reasons, and in this way a conning-tower, adapted to the use to which it must be put, will eventually be designed and installed. In these preliminary maneuvers the bridge wheel may be left connected and tended, for in emergency all means must be used to avoid a collision.

BATTLE REHEARSAL OF A UNIT.

As mentioned above in this paper, it is expected that all vessels will have battle-practice eventually, the time being dependent on the rapidity with which we train and keep our qualified pointers. It is too expensive and ill-advised to have a battle-practice with high-priced service ammunition before the ships have worked up to it. But why wait until this time before *rehearsing* your ships in battle-practice? The material necessary for rehearsal is cheap, most of it is already on hand, and the remainder can be gotten ready in a few months.

The rehearsal is accomplished by firing sub-caliber ammunition in all guns of the main battery and controlling this fire exactly as would be done in battle with service ammunition.[1] The range, size

[1] In Professor Philip R. Alger's Prize Essay, "Gunnery in Our Navy," published 1903, in a footnote he said:

"It has been suggested to me that experience in fire control may be gained by firing, using subcaliber attachments. This certainly deserves a trial."

The suggestion, I believe, was from Lt.-Comdr. V. O. Chase, U. S. Navy. It is believed by the author that many men in the service have had the idea in mind. The object of the essay is to bring the idea before the navy in hopes, if it will stand the test, to adopt it.

of target, and sub-caliber gun in rehearsal bearing a certain proportion (explained later) to the range, enemy's ship, and the real gun in action. The fire-control party and spotters are located at a height above the water from which the spotting, by the vertical method, will be exactly similar or in proportion to the spotting and control at the battle range taken as 6000 yards.

For this work each big gun, 13-inch, 12-inch, and 8-inch, is fitted with 6-pounder sub-caliber attachment, and the smaller gun, 7-inch, 6-inch, 5-inch, and 4-inch with 1-pounder sub-caliber attachment. The guns below 7-inch are considered to be but slight menace at 6000 yards on account of their small danger space and slight penetration; however, it seems better to exercise their crews with the rest so long as we have such guns on our battleships. The mode of firing, either at will or by salvos to be followed as directed, and appropriate firing intervals should be allotted to each caliber gun.

The following calculations are believed to be correct. The 12-inch work was from Bureau of Ordnance Range Table of December, 1906, and the 6-inch, 6-pounder, and 1-pounder from an old range table book published in 1893. New range tables could not be obtained.

12-INCH 2700 F. S. AND 6-POUNDER 1870 F. S.

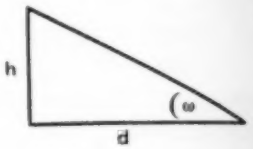
At 6000 yards the angle of departure for 12-inch is 2° 55′.8, angle of fall 3° 43′, time of flight 8″.03. Danger space 20-foot target 104 yards.

With an angle of departure of 2° 55′.8, the 6-pounder 1870 f. s. gives a range of 2216 yards, angle of fall 4° 22′, time of flight 5″.32.

Our enemy is supposed to have a vulnerable height of 30 feet. A shot perfectly aimed, with a sight-bar range of 6000 yards, provided, of course, that the distance is exactly 6000 yards and all conditions are normal, will hit the water-line of the enemy or target. To raise this shell to the bull's-eye, vertically, will require an increase of range of $\frac{15}{20} \times 104$ or 78 yards. This will necessitate increasing the angle of departure from 2° 55′.8 to 2° 58′.8. The angle of departure 2° 58′.8 gives a 6-pounder range of 2240

yards, an increase of 24 yards against 78 for the 12-inch. The angle of fall of 6-pounder with range 2240 is 4° 28′. From this we can calculate how high our sub-caliber target must be in order that the control of the 6-pounder shell will follow the exact law of the 12-inch within limits.

$d = 24$ yards,
$h = d \tan \omega$,
$= 72 \tan 4° 28' \therefore h = 5.6$ feet,

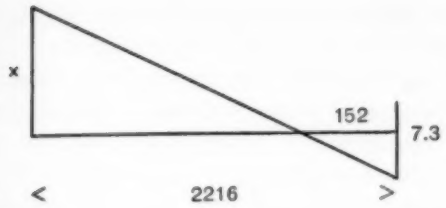


or our sub-caliber target should be given a height of 11.2 feet and be placed at a range of 2216 yards.

The danger space of a 30-foot target for the 12-inch is 156 yards or 5.2 yards per foot of target. To raise the shell one foot on the battle-target the range is increased only 5.2 yards and as the angle of elevation of the large and small gun are always the same, the sub-caliber shell will be raised $\frac{11.2}{30}$ of a foot on its target by each increment of change of 5.2 yards on the 12-inch sight-bar.

In action the shots will be spotted and the fire controlled from the tops. We shall take the height as 80 feet for the following calculations:

A 12-inch (or any shell) spotted from a height of 80 feet at 6000 yards, if short by 100 yards, will appear to have splashed on the vertical plane through the target, 1⅓ feet below the water-line of the enemy. Five hundred yards short will appear to splash 7.3 feet below the water-line, the measurments being estimated against the known dimensions of an enemy or a target. Now, having seen the shell strike apparently 7.3 feet below the water-line of the enemy, the fire-control will raise the sight-bar from 6000 to 6500 to bring the shell to the water-line. This increases the angle of departure of the big gun from 2° 55′.8 to 3° 14′.9 or a difference of 19′.1. This will increase the 6-pounder range from 2216 yards to 2368 yards or a difference of 152 yards. Now we must find the height at which a 6-pounder shell appearing to strike 7.3 feet below the water-line of the sub-caliber target will have fallen short a distance of 152 yards.



$\frac{x}{7.3} = \frac{2216 - 152}{152}$ from which $x = 99$ feet will be the proper height for the fire-control party, and if a sub-caliber shell appears to strike 7.3 feet below the water-line of the sub-caliber target an increase of 500 yards on the 12-inch sight-bar will bring the sub-caliber shell to the water-line of its own target. And further raising the 12-inch sight-bar 78 yards will bring the 6-pounder shell on the sub-caliber bull's-eye. In other words, the perspective is exactly the same, the big gun firing at a 30-foot target at 6000 yards and the 6-pounder sub-caliber gun at an 11.2-foot target at 2216 yards, the only difference being the change of location of our spotters from 80 to 99 feet above the water.

In regard to the difference in size of the splash of these two caliber projectiles, as the size as seen by the observer will vary inversely as the square of the distance, the difference will not be very great between the splash of a 12-inch at 6000 yards and a 6-pounder at one-third the distance. The same glasses (binoculars) as will be used in battle should be used.

In working out the data for the smaller calibers, a 6-inch 40-caliber of 2150 f. s. and a 1-pounder of 1800 f. s. was used as an example.

The range for the sub-caliber target was found to be 2644 yards, with a 6-inch sight graduated to higher velocity this could be decreased to the same as for the 12-inch.

The rest of the calculations are:

Height for sub-caliber target, 19.2 feet.

Height from which to spot, 82.7 feet.

Danger space, 30-foot target at 6000 yards, 50.5 yards.

A variation of a few hundred yards might make a few shots that would have hit the 6000-yard target miss our sub-caliber target, but this will hurt the results but little.

If the big-gun target and small gun (6-inch, 5-inch) are found to be of different size for guns now installed on a ship, the inside

target may be black and the outside edge white, and the hits apportioned according to the size of the caliber.

For this work sufficient accuracy could be obtained by designating a mean range[3] and size of target for certain classes of ships, the older ships might require a slightly different size. However, for practical purposes the range and size above will do for all ships.

A ship fitted out with a complete set of sub-caliber, with all her calculations made, her fire-control drilled, and her communication system in good order can now go out and have battle rehearsal. For the fire-control party, including spotters and sight-setters, everything will be as it would be in battle, except there will be no loud reports of the discharge of the great guns, and no bursting of the enemy's shell about them.

BATTLE REHEARSAL OF A SQUADRON.

After the ships have held their battle rehearsal and after all the defects in communication have been repaired and changed to the satisfaction of the officers who will have to use them, then a division will be ordered out for rehearsal to be maneuvered as if in battle by the division commander. Then rehearsals by squadrons and fleets will work all hands up to what the *real* thing *really* is. In the rehearsals by squadrons and fleets a scheme should be arranged beforehand by the umpires in order that the squadron commander himself will not know what is expected of him until his squadron is steering for the target enemies. In other words, he will know what the rules call for, but will not know from which side he will have to approach the targets, thus giving him an opportunity of handling his squadron as might be done in action in order to gain an advantage in position.

In these battle rehearsals the point to be always kept in mind is that this is a means of becoming familiar with conditions that will exist in battle, and it is the only way, in time of peace, that seems to carry out the idea of unity.

[3] Suppose a mean range of 2000 yards is adopted. *Missouri* class 12-inch, 2700 f. s., 6-inch, 2800 f. s. Now angles of departure of the sub-caliber guns to reach this range are: 6-pdr. 1870 f. s.= 2° 31′, 1-pdr. 1800 f. s.= 4° 19′, and the respective big gun sight bars will read 5311 yards and 6534 yards. As before using 30-foot targets, we (from the danger spaces at 5300 and 6500 yards) get the increased angles of departure to hit the top of the target to be respectively 2° 37.2′ and 4° 24.3′, which gives us our sub-caliber danger spaces of 50 yards and 23 yards. The angles of fall being 6-pdr., 3° 42′ and 1-pdr., 8° 12′, give us heights of target 12-inch, 9.7 feet, and 6-inch, 12.5 feet. The spotting heights will be respectively 109 feet and 90 feet.

It is not a training to shoot; the gun-pointers get but little benefit, and we learn nothing of the many accidents and delays incident to using our monster tools with full charges, but it trains the brain of the ship and the brain of the fleet to act quickly and with precision.

It will show us our errors in a striking and forcible way. We know some of our weaknesses, but, unfortunately, do not know the remedies. Our points of weakness are: Battle signaling, *maneuvering* in *battle trim*, and fire-control. I shall try to show how the battle rehearsal will aid us to a solution of all three.

The maneuvers now engaged in by our armored ships are worth while in teaching the young officer how to handle a big ship, to rub the nervousness out of him; but they do not teach the commanding officer how to handle his ship in fighting trim.

Viewing a ship engaged in maneuvers, what do we see? The officer of the deck, tactical signal book in hand, on the flying bridge, the helmsman near his hand. From this high point the view is uninterrupted; it embraces nearly the thirty-two points of the compass. On the bridge with him are a small army of helpers; a man for every mechanical device needed for the work of handling the monster fighter; a signal officer; may be the navigator; probably the captain, near at hand in the chart-house below him. The officer of the deck gives no concern to aught save the steering; this keeps him very much alive. Suddenly, commencing with the flagship and travelling down the column with wonderful rapidity, a signal is flown of varicolored flags, often two or three hoists in all. The numbers are called out to him by the signalmen and inside of two minutes he knows what the next maneuver is to be. If the flags on the flagship or repeating ships had fouled or were end on, or if on account of smoke or light, a red was mistaken for blue, four or five minutes may elapse before the last ship has repeated the signal and the maneuver may be commenced. However, this teaches our young officer and also the captain but one thing: how to handle the ship from an excellent seeing locality, but one untenable in battle.

Imagine an officer in the conning-tower in maneuvers such as our fleet has been having lately. He has a restricted view through the slit holes in the armor from ahead to a little abaft the beam on each side. He cannot read signals himself, for he cannot use his glasses with any degree of certainty. In a maneuver when

he puts over his helm, his view being limited, he does not know where the vessel astern may be. It may be unsafe for him to change his course just then. The location is a new one. Not since Santiago, if then, have ships been maneuvered from the conning-tower. Much of the nervousness may be only stage fright and may wear off after several rehearsals.

Below are given tentative rules for battle rehearsals. I do not claim them as complete, only something concrete to build upon.

RULES FOR BATTLE REHEARSALS.

The size of the sub-caliber target will be the same for all ships using the most modern sights.

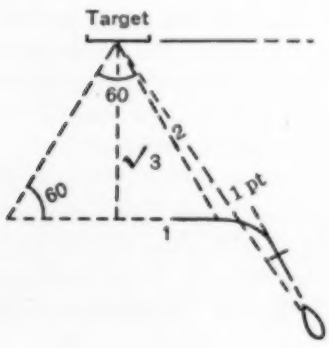
Those ships with old sights and low velocities will calculate and submit the required size of their targets to the Bureau of Navigation.

No guns will be fired of smaller caliber than 4-inch. Six-pounder sub-caliber guns will be fired in guns from 8-inch to 13-inch, and 1-pounder sub-caliber in guns from 4-inch to 7-inch.

The target for single-ship battle rehearsal will be spread on standard target raft and anchored by standard moorings.

The ship engaging in battle rehearsal will approach the target on a course making an angle of 60 degrees with the plane of the target and with the target bearing 1 point on the port bow if ship is to turn to port, if to turn to starboard then 1 point on the starboard bow.

When ship reaches range, as shown by range-finder, of sub-caliber range (equal to $\frac{2}{\sqrt{3}} \times$ middle range) plus her advance to turn parallel to plane of target, she will put her helm hard over and steer a course parallel to the plane of the target. Immediately the ship is straightened on the course the whistle will be blown once to commence firing. The end of the run will be when the target bears 30 degrees abaft the beam of the firing ship, and the signal to cease firing will be two blasts of the whistle. Each ship will fire first one battery and then the other without change



of target, unless the one used has been reduced in surface by gun-shots. Guns that train on both broadsides to be fired on each run. Pointers and sight-setters will not change during a rehearsal, but the pointer who fires at one practice will set sights the following practice. All ships must be handled from the conning-tower and all officers and men must occupy the stations assigned them for battle. The speed will be the maximum attainable, umpires will be appointed to see that the rules are followed in every particular.

After the practice, the target or targets will be brought on board the firing ship and the hits counted and assigned by the umpires. The hits per gun per minute of the two classes of guns will be calculated by the firing ship and submitted immediately after the practice to the Bureau of Navigation.

As soon as all ships have completed this practice, a circular will be issued by the Bureau of Navigation giving the results by ships, with the score and standing, and this standing will be considered the measure of relative efficiency of the fire-control of each ship of the navy.

Vessels whose systems of communication for fire-control are old and inefficient, through no fault of the ship, will be put in a class by themselves for this competition, as it is manifestly unfair to force a competition between a vessel with a new and approved fire-control system and one whose system is known to be obsolete and unreliable. The above practice to be held not less frequently than three times in each year.

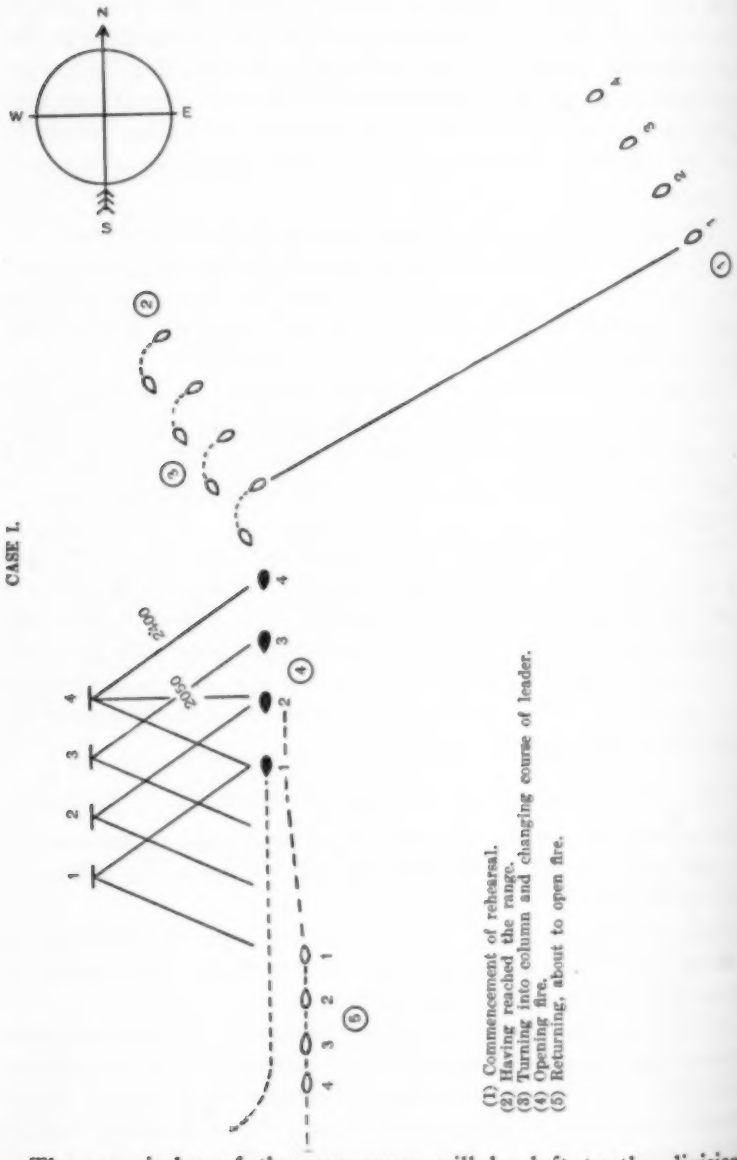
RULES FOR DIVISION REHEARSAL.

The rules for battle rehearsal by ships to hold in the case of divisions as far in as it does not conflict with the following instructions:

The targets are to be of the approved size and anchored in column, screens in the same plane at a distance apart measured from center to center of 400 yards.

Umpires, to be appointed by the commander-in-chief, on going aboard the flagship of the division commander, but not before, will direct him to proceed with his division to a locality shown him on the chart. Upon arrival there to form his ships in line, the course to be steered will be the bearing of the end near target. If possible this target should be kept a little on the near

bow in order not to cut the rear ship too close on her turn on the range.



The remainder of the maneuver will be left to the division commander, except that he must steam by the anchored targets in

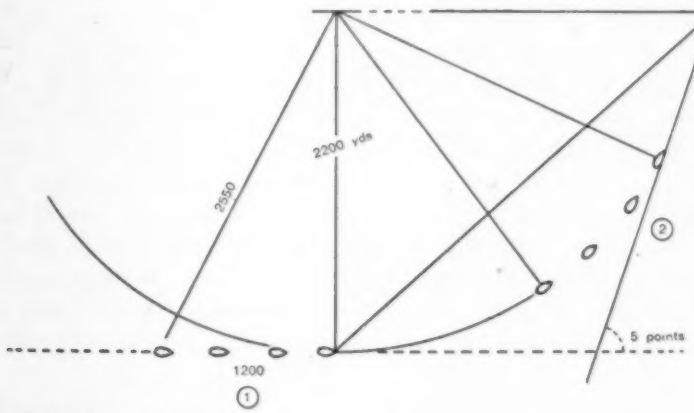
column formation, each ship opening fire when its target bears 30 degrees forward of her beam and ceasing when it bears 30 degrees abaft the beam.

Upon the completion of the first run the targets will be changed, and the division will then return, firing the other battery. The leader on this run will fire at the target on the opposite end, the far target.

This will end the first stage of the rehearsal. Concentration will be used in the second stage as follows:

The targets are changed. The division commander will steam on a course parallel to the plane of the targets at a mean sub-

CASE II.



(1) Opening fire (concentration).
(2) Ceasing fire.

caliber range, and so that each target when abeam will be approximately 2200 yards. When the far target is abeam of his ship, he will direct fire be opened, concentrating on the target or targets given him by the umpires, and will steer his leading ship on the arc of a circle, with this target as the center and radius equal to 2200 yards. The other ships following in wake of next ahead without signal.

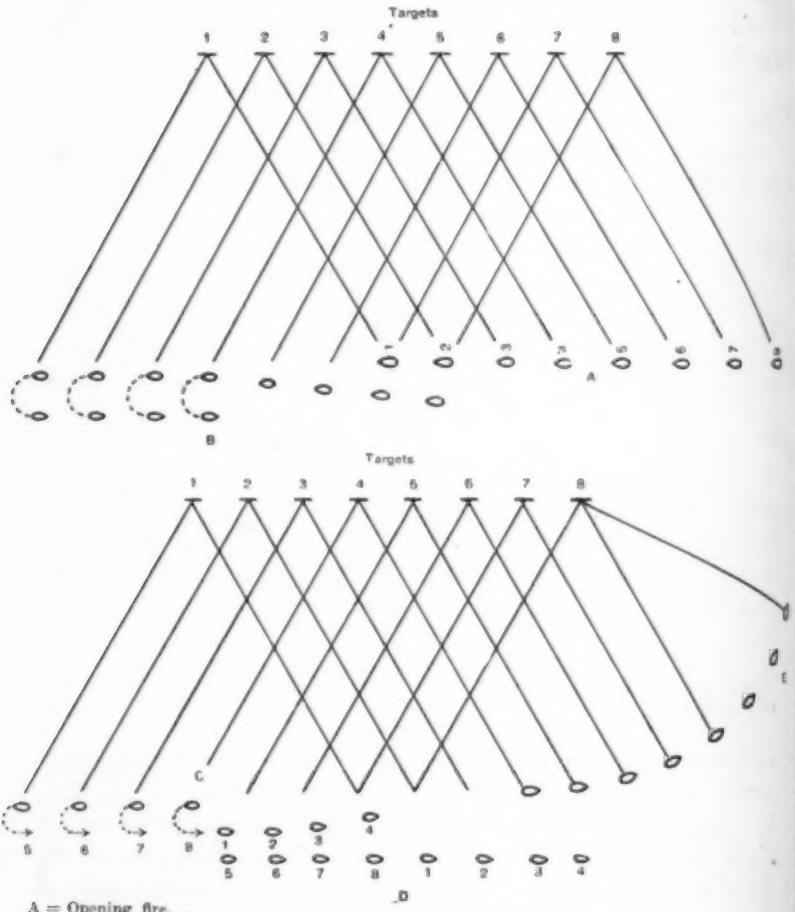
Fire will be ceased when leading ship has turned through 5 points of the compass.

The relative merit will be shown by divisions in the Bureau of Navigation's publications.

Division battle rehearsal to be held not less frequently than one in six months.

RULES FOR SQUADRON AND FLEET BATTLE REHEARSAL.

The rules for squadron and fleet to be the same as those for single ships and divisions in so far as they do not conflict with the following:



A = Opening fire.
B = 1st division going left about; 2d division changing targets.
C = 2d division going left about; 1st division about ready to open fire.
D = Squadron in column; 1st division firing at targets 5, 6, 7, 8, leader about to steer on arc of circle shown; squadron to open fire and concentrate on targets 7 and 8.
E = End of rehearsal, leader having turned through 5 points. (Ships are displaced for clearness.)

The number of targets anchored will be equal to the number of ships taking part in the battle rehearsal.

At the commencement, similarly to the rule for divisions, each

ship will fire at the target bearing the number that she herself holds in the column of engaging ships.

The time of opening fire will be when their targets bear 30 degrees forward of their beam.

[The rules here given are for a squadron only, it being considered inadvisable and may be impossible to provide a sufficient number of targets for a fleet.]

When the leading ship of the squadron reaches a position where her target (No. 1) bears 30 degrees abaft her beam, the division of which she is the leader will cease firing and each ship of this division will turn, simultaneously (by signal), about away from the targets.

The second division will immediately shift their fire to the targets, in natural order, of the leading division and will continue to fire until the leader of this division has reached the position where her new target bears 30 degrees abaft her beam, when the second division will turn about (by signal) away from the targets, ceasing its fire before turning exactly as done by the first division, and will follow in column the first division already turned. The first division will now open fire on the targets of the second division in reverse order, that is, leading ship will fire at leading target (so as not to cross the fire) as soon as the target of each bears 30 degrees forward of her beam.

Concentration of fire.—When the leading vessel of the squadron arrives at a position where her target will bear abeam, she will steer on an arc of a circle with the distance of the target as a radius, followed in wake by all the rear ships.

The second division will now open fire and the two end targets (ahead) will be used. The first division using target No. 8 and the second division No. 7 target. Fire will be ceased by all ships when the leader of the squadron has turned through 5 points of the compass.

This will end the rehearsal battle practice.

The score in hits per gun per minute will be calculated for the squadron, and the standing of squadrons will be published to the service by the Bureau of Navigation.

Squadron battle rehearsal to be held once a year under their squadron commanders.

AN ELEMENTARY STUDY IN FIRE-CONTROL.

Fire-control has been divided for convenience into fire-control and spotting. The former has been defined as the art of transmitting the correct ranges from the fire-control party to the batteries, and spotting the art of knowing quickly and accurately where the shells are hitting.

The efficiency of both of these arts will be shown in a striking manner in a battle rehearsal, but there has been devised a system of training spotters without even firing a gun. These elementary lessons in spotting (teaching those who will have to control the fire of our ships, the A, B, C's, as it were, of this craft, in order that they will have had some training even before the battle rehearsals) can be given on board ship, and the game, so-called, bears a striking similarity to the real thing, without the discharge of the gun to disconcert the observer until he has accustomed his mind to act quickly, taking the observations of his eyes and converting them into mystic numbers, the key to which the fire-control party are holding.

The urgent need of good, reliable spotters is well-known. This duty requires good, strong eyesight, calm, accurate judgment, and intense interest. The spotter must be ever keenly alive, unhesitatingly, to make up his mind where the shot or shots fell and give the corrections to the sight-bars quickly for the next shot. The tension under which he will work in battle and even at target practice will be enormous, and for this duty he should receive daily training, in order that his eye and brain may work in perfect synchrony.

For this daily training, without the expenditure of ammunition, the *dotter* of fire-control has been devised and perfected to some degree by officers in the Atlantic Fleet.

THE DOTTER OF FIRE-CONTROL.

The method of training is that of representing in concrete form the sea and target and placing the eye of the spotter at a height in proportion to the distances. In other words, "spotting in proportionate miniature."

The instrument[a] in use on board a vessel of the Atlantic Fleet was constructed as follows:

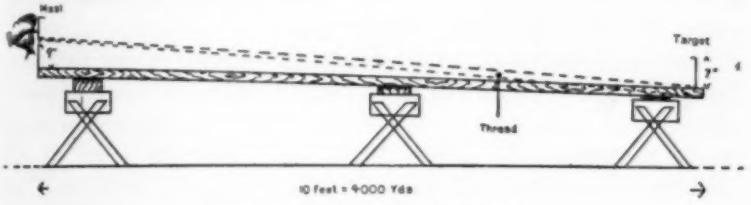
[a] "The idea of the spotting board was suggested to me on board the *U. S. S. Indiana* by Lieut.-Comdr. A. B. Hoff, U. S. N. Together we constructed the miniature target and peep-hole-card, using cardboard, and

A well-seasoned board, ten feet long, was obtained. The top was planed down as smooth as possible and sandpapered, then painted a light green to represent the surface of the sea.

This board represented a distance of 4000 yards, or 400 yards to the foot.

The target was made of sheet-tin, painted black to represent the long-range target.

As the new long-range target was 30 feet by 60 feet, the dimensions, in proportion, of the miniature target should have been .3 inch by .6 inch, but the eye of the observer was supposed to be looking through 12-power glasses, which gave as the size of the target 3.6 inches by 7.2 inches.



THE DOTTER OF FIRE CENTRAL.

The mast was represented also by a piece of tin, about a foot wide, with an eighth-inch slit, the width of slit being a little greater than the distance between an observer's eyes. The top of the slit was at a height of 9 inches.

Working out the proportion, if the height of the spotting station was 75 feet, the height of the slit should have been .75 inches, but we have made the target 12 times larger to represent it magnified, so in order to preserve the angles in their correct measurement, the height of the eye was multiplied by 12 also. Thus showing graphically the enormous value of good high-power glasses when spotting by the *vertical method.*

Having the game completed and set up on a table or a couple of wooden horses of the proper height, we are ready to give the

demonstrated the feasibility of the system on the mess table covered with a green baize table-cover. We found the nap of the cloth raised the thread so far above the plane of the table that the eye was deceived in its estimates of distance, so afterwards the board mentioned in the text was constructed and used before I was detached from the ship as her ordnance officer. I sent a description of our board to Lieut.-Comdr. Mark Bristol, Fleet Ordnance Officer Atlantic Fleet, last September and it may now be used by other ships of the fleet."

[4] Should be 3.6 inches in height instead of 7 inches as shown.

recruit spotter his first idea of how to correct the range by observation of splash.

The observer places his eye, at one end of the board, to the slit in the tin fastened to the board itself, and glances with both eyes open at the target. The target seen seems very lifelike.

A small piece of cotton-thread is put down across the board at any distance between observer and target. The observer estimates the apparent number of feet the splash is short (by vertical method, using target as a visible scale), consults his table and calls out "up so many hundred yards." The attendant measures the distance by a scale made for the purpose, and taking up the piece of thread puts it down in its new place. If a spot puts the next shot on the target or over the observer is told, and makes his next correction accordingly.

The board described is for 4000 yards only but it may be made for any range. A ship as target would be more lifelike, but these officers were training only for target practice, so the *ship* was of no use to them.

Below is a scheme of shapes for battle signals to be used at rehearsal. They explain themselves. The writer believes that something similar to this is bound to come and the more thought put on this matter, together with the actual experiences that would be gained in rehearsal, the quicker we shall decide what is the best for the purpose:

Two-element signal is a simultaneous movement.

First in hoist designates direction.

Second in hoist designates number of points through which each ship will turn.

First in Hoist.	*Second in Hoist.*
△ To the right.	○ 4 points.
▽ To the left.	△ 8 "
	▽ 12 "
	□ 16 " or about.

Three-element signal is a successive maneuver.

First in hoist designates direction.

Second in hoist designates number of points through which leader of new formation will turn.

Third in hoist designates the first ship of a division as the leader.

First in Hoist.	*Second in Hoist.*	*Third in Hoist.*
△ To the right.	○ 4 points.	○ Leader of 1st division.
▽ To the left.	△ 8 "	△ " " 2d "
	▽ 12 "	▽ " " 3d "
	□ 16 "	□ " " 4th "

Single Element Hoists.

Ball. ○ Right about in succession of divisions.
Cone. △ Ships right about.
Top. ▽ Ships left about.
Drum. □ Left about in succession of divisions.

The leader of a division is the leading ship in the division, not counting any vessels which have been sunk or fallen out of the formation.

Having described in some detail what I have termed the battle rehearsal, I would like to take the reader on board the flagship of a squadron during its annual rehearsal.

All preparations for fire-control have been tried out in the single-ship rehearsals. Each ship has been fitted with a conning-tower similar to the one described on a following page of this article.

Eight battleships steam out in column from the anchorage near the target grounds. All are cleared for action—in fighting trim. The chief umpire has given to the squadron commander the position from where the rehearsal will be commenced.

All hands are at their assigned stations for battle. Instead of the swarm of officers and men on the commodious bridges, these have been removed and grim tubes peep up above the armor of the turrets. Inside these armored tubes the captains and their signal officer and men are attentively watching the next ship ahead for the first sight of the small shapes that will notify them at a glance the wishes of their squadron commander. The captains speak in quiet tones to their executive officers below them in the tube, cautioning to guard the steering carefully.

The squadron commander in his after tower is glancing off to starboard at the small targets some miles across the water. He knows the targets are moored in a north and south line and he has reached the position given him by the umpires.

His chief of staff below him in communication with the wireless room below and the squadron commander above him, receives a change of course from his chief and sees the helm put over; the leader swings away from the direction of the targets. Each vessel astern follows in column without signal. When all ships have formed in exact column, the commander speaks a word to his flag lieutenant by his side and two shapes are run up to the yard-arm. Two cones appear at the yard-arms, almost simultaneously, of the nearer ships and in but a few seconds the last

ship in the column has answered and understands the signal. Ships right—8 points is executed, and on approaching the rehearsal range top cone puts the squadron again in column, heading nearly parallel to the plane of the targets. The leader steers the proper course, the other vessels follow without question.

From here on the rules are followed.

The fire-control party work as they would in battle.

A drum alone hoisted on the flagship and hauled down by the first division sends that division ships left about. The second division shift targets, continue the fire, and keep their drums flying at the yard-arms. In but a few minutes this division has turned and is in column again, and so it goes to the end of the rehearsal.

All are given training for battle. The gun-crews, handling-room crews, and gun-pointers are trained to a less degree, but the two annual target practices give these their necessary training.

One criticism may be made on this system which I shall answer before it is made. As the guns are all being fired at once it is improbable that a gun-pointer can see through his telescope where his shell hits; he would probably mix it with many others, so that he could not possibly make his own estimates.

The important point is we will be doing the work, and at but small cost, which we shall have to wait years to do if we put it off until we have sufficient qualified gun-pointers to shoot our guns with service charges.[8] This would be the Morris tube of fire-control.

A PROPOSED CONNING-TOWER AND THE DUTIES OF THE SENIOR OFFICERS IN BATTLE.

It is believed that the present style of conning-tower is a mistake, but if the ship is maneuvered from it, this point will be soon cleared up. There is no doubt of that, and now is the time to find it out; not when we are about to engage the enemy.

[8] After writing the above, I feared that those readers of the Institute unfamiliar with the requirements of gunnery training might believe that this practice could take the place of battle practice, using full charges. I wish to state emphatically that it cannot. Battle practice is absolutely necessary. The above is but gallery practice to drill the fire control party, etc., for the battle practice. Our battle practices should be more successful for this training.

Another and an important question will be answered by these rehearsals, one that is now in an uncompleted state. I refer to the duties as outlined in the U. S. Navy Regulations for the higher officers of our ships. For instance, article 546 reads:

Executive Officer.

"(1) In battle he shall look after the general working of the armament, and from time to time repair to any part of the ship where this duty may be performed to the best advantage.

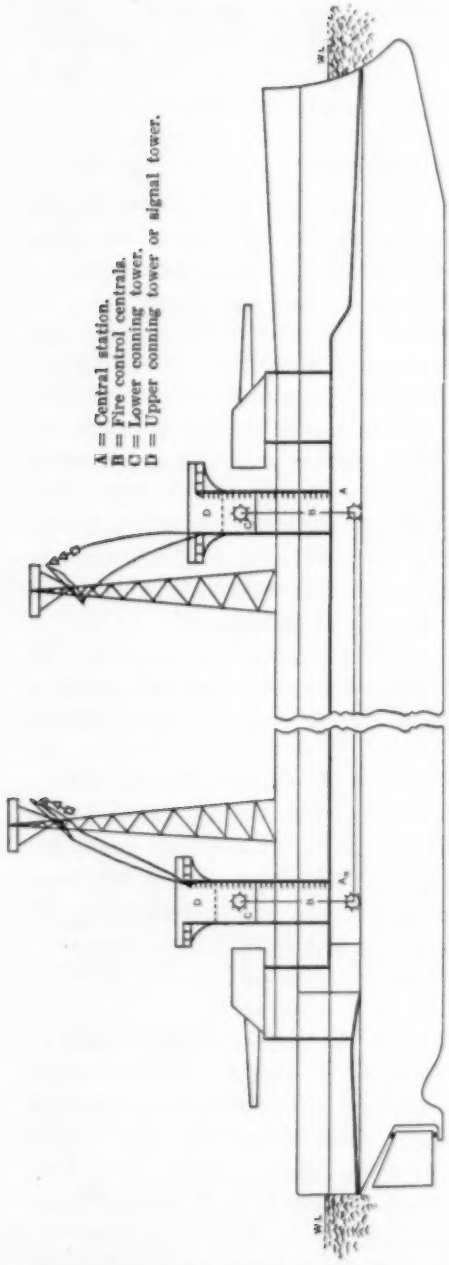
"(2) If boarders are called away he shall lead them."

He could not perform this duty in a modern battleship. He might just as well commit suicide as to attempt it. He is not, or ought not to be, charged with the performance of the battery. The battery officers alone should be responsible for the behavior of their guns after the action fairly commences. The executive officer is logically the man to be protected and saved to take command of the ship in case the captain is disabled. Boarders are an adjunct of battle too ancient to be considered in these modern days, except in case of the surrender of an enemy, in which case a less important officer should be sent as prize master.

Undoubtedly a change or two will be brought out by familiarity with the conditions of battle, imitated by the rehearsal, but as a starter we cannot go far wrong if we station our high officers as outlined below:

The captain should be in the conning-tower with his helmsman and a man, or better, an officer, for communication. His main, and almost sole duty, is to handle his ship and designate to the fire-control central the change of target as signaled from the flagship or given by prearranged plan at different stages of the combat. His signalmen must be near him and the signals, if he does not read them himself, should be given him by "word of mouth," any other means would be untrustworthy.

The executive officer should be in the central station, where he can keep in touch with all batteries, magazines, engine-rooms, etc. He should cull out the important information to transmit to the captain in the conning-tower. Then, if his turn came to take command, the situation would be his after a glance about him. If the central station were at the foot of the armored tube containing the conning-tower, a ladder might be worked in for communication, very nearly as arranged in the military masts of to-day



for reaching the tops. (See below, duty of executive officer in new conning-tower.)

The navigator should be near the captain to advise him of dangers in navigation. His duties as officer of the deck seem to fit his usefulness. He should pay especial attention to signals.

The ordnance officer may be either in the fire-control central or in one of the fire-control tops. He should not have to visit any part of the armament during an action. If the crew of a gun or turret cannot repair a breakdown, it would be better to lose the services of this unit rather than cut the head off fire-control by sending this officer away from his station.

It may seem too radical to our avowed policy of no changes unless the change can be shown to be beneficial, but with the hope that this recommendation may need no further proofs than I have at hand, I shall describe and show the good features of a conning-tower proposed by an officer[6] of the Atlantic Fleet.

[6] Lieutenant H. C. Dinger, U. S. Navy.

In the sketch representing a battleship a heavily armored tube is run up from the protective or armored deck to a height so that from the top a clear view can be obtained. The tube, depending on the size of the ship, should be large enough, in internal diameter, to accommodate comfortably the officers and men who will be stationed on its different flights or decks. The tube should have no permanent top, but about a foot below its top rim a light wooden or steel deck is worked to be used as a bridge in ordinary cruising. A wooden chart-house, easily removed, may be built abaft this tube. On the top deck of the tube will be stationed the captain, the navigator, and four signalmen, also an officer for communications. The deck of this top flight to be formed of iron gratings (armored), with large speaking-tube connections to the next lower compartment. The top compartment we shall call the conning-tower "D." The floor should be movable and placed at such a height, by appropriate means, so that the principal occupants may just see over the top rim, and exposing but a small part of the head. In the compartment "C" just underneath is the wheel and here are stationed the helmsman, the executive officer, and an officer or man for communications. The compartment "B" may be used as the fire-control central; it is above the armored deck but well protected by turret barbette, vertical and diagonal armor. The central station is located at "A," and in this station should be one or more intelligent men under charge of an officer. The central station should be of good size and contain all the necessary instruments for communication without cramping. A skeleton mast is shown with signal shapes at the yard-arm. In a flagship this tower should be repeated aft, and in fact in any ship, for it provides an extra place for steering in case of accident forward and gives a duplicate fire-control central.

In the flagship on the deck of compartment "D" would be the admiral, his flag lieutenant, and signal force. At "C" would be the chief of staff (to succeed to command), a helmsman, and a man for communications. In "B" a second fire-control central. Each top to be used by fire-control parties.

The idea of putting the executive officer in the compartment below the captain is to more fully protect him, and to regulate the steering from directions received from the captain in the conning-tower above.

The same explanation holds for the chief of staff, and the admiral may want to con his own flagship.

The above tower seems very practical and I believe will appeal to most navy men. It seems simple of construction and might even be installed in those ships already in commission, thereby greatly increasing their tactical value in battle. The metal of the old tower might be cut out and this new tube of better and lighter armor worked in its place. In addition, all the heavy, but unarmored metal, should be torn away from the vicinity of the top of the tower, as it would be a menace to those inside and would confine the gases of bursting shell.

These thoughts have led the writer into a broader field than it was his intention to attempt, but if the mention will make sufficient noise for our thinking and doing men to hear I shall be glad to have diverged from my original subject.

The supreme test of any plan is what good results may be logically expected from its adoption. These are a few points which the writer believes will be cleared up in battle rehearsals:

(a) Fire-control will be put on a smooth, running, intelligible basis.

(b) The duties of all officers in battle will be definitely settled.

(c) We shall know which officers in our navy are proficient and skilful in their profession.

(d) Concentration of fire can be exemplified, the value of bow, broadside quarter, ahead and astern fire may be graphically shown.

(e) If nets are spread underneath the targets, the value of short-range torpedo fire may be tested.

(f) Many officers will be trained as spotters.

(g) Ship construction for battle purposes will have a new light thrown upon it.

(h) The navy will be training logically to fight a fleet action—perfecting its team work.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

SEA-STORES AND REFRESHMENTS.

EXPERIMENTS AND ACCIDENTS IN NAVAL DIET.

By CAPTAIN C. G. CALKINS, United States Navy (Retired).

No attempt to investigate the sources of naval history, whether these relate to voyages of discovery or to warlike campaigns, can escape the perennial problem of supplying seamen with food and drink when keeping the sea or seeking relief in inhospitable ports. Unless all facts relating to diet are neglected there must be an accumulation of notes concerning victuals altogether out of proportion to the space allotted to such vulgar materials in standard histories or professional discussions. Whatever may be the practical or scientific value of such by-products of research, these notes should offer certain elements of human interest, though rather of the naturalistic than the romantic order. At any rate, the much-enduring sea-farers of all ages have taken pains to record their traffics and adventures in search of nutrition, not sparing crude details which compilers have thought beneath the dignity of history and which red-tape administrators and economists have been content to ignore altogether.

From a file of notes on problems of diet a selection fit to satisfy the curiosity of the general reader and to furnish suggestions for the special student can readily be made. While they cannot be made exhaustive and will not attempt to be scientific, they may provide raw material for those capable of organizing data according to the principles of dietetics and economics. The number of naval officers bound to concern themselves with such matters has been enlarged by the assignment of paymasters to commissary duty, and surgeons will need special knowledge inaccessible to their fore-runners if they are to keep pace with the new school of theorists styled dieticians. The Army has also recently encountered the problem of feeding recruits on the high seas and in

tropical countries. The results of the experiments of 1898 might have been edifying had not the details been held unfit for publication. Of course it must be admitted that dietetic discussion cannot be liberated from all restraints. Modern efforts to emulate the unsavory indiscretions of eighteenth-century English novels can only be excused by actual results in promoting reform in the commercial processes of preserving food. With such reforms this paper has no concern—being, in fact, destitute of any critical or contentious aim—and it is hoped that it can be read without physical discomfort. Thus Smollett is excluded from our list of authorities—though Macaulay made his novels a capital document for the defamation of great seamen who were not of Smollett's century—and the latest revelations from Chicago will also be ignored. Cannibalism, afloat or ashore, is naturally a fit subject for exclusion.

On the other hand, various obsolete beverages and their hygienic and disciplinary associations with life at sea will demand more or less consideration. The benefits conferred by modern methods of supplying pure water throughout the longest voyage are now generally recognized—though recognition was long delayed by untimely survivals of the economic instinct—but earlier improvement due to the partial substitution of cheerful beverages for inebriating liquors often no less unwholesome than demoralizing, have been less adequately described.

In general this study relates to primitive conditions and uncommercial and unofficial methods of supply. Neither price-lists nor ration-tables will be set forth in these pages. Yet it may be assumed that the food supply of sailors has always been subject to certain elementary rules. Without attempting scientific or historical accuracy, the essentials may be stated as follows: Supplies must be cheap, that is, abundant where the stock is to be obtained; compact for stowage; fit for keeping; nutritious, wholesome, and palatable enough for the conditions under which they are to be consumed; and comformable to the habits of the class from which recruits are drawn. Some of these requirements are so modern that they are still inadequately recognized in practice, while others have always been observed, at least in theory. Cheapness is the reef upon which most hungry and ill-fed mariners have been cast away. Yet crude methods of curing meat and carelessness in stowing bread have been hardly less destructive. Disregard of

the climatic conditions of a voyage and conformity to home habits when these were unsuitable have also slain their thousands. Thus because of the prominence of beef and beer in the traditional diet of England, crews were sickened with sour beer and poisoned with salt beef for many unhappy generations.

If we follow the precedents of simple-minded antiquarianism and begin with the chronicles of classical navigators, Herodotus proves less helpful than might have been expected, considering his insatiable curiosity and his frank domestic detail. Perhaps his voyages were too short to enable him to resume his interest in food before reaching port. His notes on Egyptian diet need little revision to bring them up to date, and he learned from monumental inscriptions how much the wonders of Egypt cost in onions and radishes. He heard that the Ethiopians despised bread-eaters and attributed their own longevity to an exclusive diet of milk and beef. The Babylonians, on the other hand, had more grain than any nation, and their date-palms yielded some compensation for the lack of figs, grapes, and olives, all of which the Greeks held to be indispensable. Herodotus knew the legends of the lotos-eaters and the Ichthyopaphagi, and he had heard that the Scythians stewed the flesh of cattle in paunches or hides hung over a fire of bones.

The Homeric poems deal frankly and respectfully with the desire of eating and drinking which so often overtook their heroes. But their feasts were held ashore where such refreshments as fresh pork and honey-sweet wine were plenty, and we know less about their sea-stores than their refreshments. They never cruised far from land, their galleys had little space for stowage, and they could fish when foraging was too hazardous.

Thucydides carries us into the midst of the calculations of a regular commissariat. When the Athenian fleet sailed for Sicily in 415 B. C. a levy of bakers went on board to supply the troops with fresh bread if the voyage was delayed by calms. Nicias also demanded that the sea-route should be guarded so that his store of wheat and parched barley might be replenished during the campaign. Experiments in concentrating food are also recorded by Thucydides. When a galley was racing to Mitylene to countermand an inhuman decree passed by the Athenian assembly, the rowers were supported by rations of meal soaked in wine. A Spartan garrison blockaded on an island at Pylos got temporary

relief by stores smuggled across from the main by swimmers tempted by the offer of reward. Helots could win their liberty by successful trips, and ingenious combinations were prepared. A paste of pounded flax-seed and poppy-seed—the latter still in use among confectioners—was blended with honey and packed in skins which were easily towed by a strong swimmer. Both Athenians and Spartans suffered from the necessity of using brackish water during this siege, and the blockaders found themselves so uncomfortable afloat that their men had to land by watches and take their meals ashore, thus leaving the ships half-manned in the presence of the enemy.

The Greeks cared little for exotic luxuries and strange meats in their best ages, and the rich viands brought over by Persian invaders aroused the contempt of the Spartan warriors. The worthy Xenophon, driest of Greek chroniclers, had to deal with many strange diets in his wanderings. His army foraged wherever it failed to find an open market, and after reaching the Euxine kept three hundred canoes cruising in search of provisions. These pillaged the stores of certain thrifty barbarians who had laid up grain, chestnuts, and loaves of bread in vast quantities. They had also stored many great jars full of pickled slices of dolphin and porpoise blubber; these substitutes for meat and oil discouraged the Ten Thousand from carrying out a project to found a pirate kingdom on the shores of the Black Sea. Olive oil was an indispensable luxury among civilized Greeks.

The campaigns of Alexander the Great vastly enlarged the digestive tolerance of Hellenic soldiers, but the naval commander Nearchus, who conducted a fleet from India to Arabia, found the Ichthyopophagi most unsatisfactory caterers. When his starving sailors captured a town they got one meal of barley-cakes and baked tunny-fish, but their demand for a ransom to be paid in grain revealed the fact that there were no sea-stores except dried fish pounded into meal, and that the country yielded no staple but fish. These were caught in huge weirs and nets made of branches and fibres of the palms. Even domestic animals had no other forage, and the mutton was as fishy as the meal. Yet fish-meal has been found edible enough in regions unvisited by Alexander. The Indians at the falls of the Columbia River dried and ground many tons of salmon after each run of the fish, and the neighboring tribes were willing to take it in trade. Lewis

and Clark also liked this food, finding it handy for transportation, as it was packed in tight bales of basket work and not apt to decay. Certain South American tribes had to live on a paste of pounded ants, which they tempered with grain or seeds when these could be obtained.

A late and corrupt Greek writer, Athenæus, gathered an unedifying volume of citations from poets and sophists dealing with the delights of gluttony and discussing such vital matters as the filling nature of bean soup and the special flavors of fish and mollusks dressed according to the repulsive recipes of antiquity. The note of nautical life appears, however, in his description of the Samian Laura, a street in the marine quarter of the capital of the pirate kingdom of Polycrates. This resort abounded in temptations for sailors, including stalls for the sale of all the salt and spicy foods which the ancients regarded as provocatives to various forms of intemperance and vicious indulgence.

The Roman and Byzantine Empires contributed little to the progress of maritime discovery and less to the improvement of naval diet. Though the cruising radius of galleys was restricted by the demand of the rowers for food, no reform except cutting down the ration seems to have been attempted. Roman citizens were fed with import-grain to secure the sort of moral order based upon idleness and satiety, as expressed in the imperial maxim *panem et circenses*. But while war could be relied upon to fill the benches of the galleys with robust barbarians, there was little care for their longevity, and the lash was the regular stimulant. The ration-tables of the last of the galleys disgraced humanity, and the artillery which disabled them did a beneficent work.

The maritime races of the northern seas had a more rugged manliness and individuality enough to guard their dietary rights. The Vikings, for instance, enjoyed a rude profusion of meat and drink afloat or ashore. A feature of all their inland raids was the strand-slaying before making sail for departing. All the cattle of the country side, including the horses ridden by the pillagers, were slain and salted down for sea-stores. Ulysses owed part of his maritime misadventures to an indulgence in strand-slaying in Sicily, while the ancestor of William the Conqueror was driven from Norway for killing cattle in defiance of the prohibition of Harold Fairhair. The long ships of the Vikings had scanty space

for provisions or passengers, and it is recorded that Harold Hardrada when chased started his ale-casks and hove his prisoners and his provisions into the sea. A milder device was suggested by an Irish thrall to a thirsty crew of Norsemen bound for Iceland. After they ran short of water it was found that oatmeal kneaded with butter—fresh butter, no doubt—would allay thirst. Besides ale the Vikings seem to have known stronger liquors, mead brewed from honey for one, and the bragging cup which the chiefs drank at high festivals gave rise to many scandalous and superhuman vows.

The rediscovery of the Canary Islands and their occupation as a commercial outpost in 1402 promoted the discovery of the New World in many ways, but chiefly by offering supplies and refreshments for hungry and thirsty mariners bound to the westward. Its resources had been left undeveloped by successive raiders and slave-hunters, African or European, and it is probable that the Norman captains, Gadifer and Bethencourt, who sailed ninety years before Columbus, found the same supply of food that Sertorius, noblest of Plutarch's Romans, would have found had he sailed to carry out his project of an island empire fifteen centuries before they attempted the conquest. The staples were simple enough, grain and fruit in Grand Canary, goats' flesh and cheese in Fortaventura, where the natives hung their meat to dry unsalted and so filled their stone huts with rank odors and became the first of the buccaneers—if that term be used in its natural sense.

Spanish and Portuguese settlers brought various fruits to perfection, and made all the groups of islands in the East Atlantic favorite stations for the refreshment of mariners, the Azores for homeward bound ships or those who lay in wait for them, and the Canaries and the Cape de Verdes for those bound for the West Indies or even for Virginia. The early English navigators always alleged their need of water as an excuse for their unwelcome visits, and they often succeeded in buying a stock of the wines which they thought no less indispensable. Whatever might be denied in trade they were eager to win by fighting, though they were sometimes beaten off by those who had property to defend from pillage. Porto Santo near Madeira was ransomed by one of the Elizabethan captains for eleven hundred hens, a herd of goats, a few casks of wine, and grapes and figs at discretion.

Raleigh on his last voyage in 1617 lingered among the Canaries in search of supplies, getting his last comfortable refreshment at Gomera, where he exchanged presents with the governor's English wife. Her gift included, Raleigh tells us, "great loaves of sugar, a basket of lemons, which I much desired to comfort our many sick men, a basket of oranges, a basket of most delicate grapes, and another of pomegranates and figs, which trifles were better welcome to me than a thousand crowns would have been." The next day he got more fruit, fat hens, and loaves of white bread. The usual epidemic accompanied the luckless voyagers on their way to Guiana, but the fruit from Gomera kept Raleigh alive until he could be refreshed by pineapples in the West Indies.

Columbus and his immediate successors showed little healthy curiosity in matters of diet, though they were eager to infer cannibalism from the Carib custom of curing ancestors on the *boucans* set up to cook their meats. As attempts to form colonies were made the Spaniards grew familiar with the staple foods of the natives, and learned to use some of them as sea-stores. Cassava, the chief farinaceous food of tropical America, makes a serviceable bread still sold in the markets of Cuba, but its preparation requires native labor and skill. The root is generally poisonous, but the poison can be extracted by grating, squeezing, and washing, and the dried flakes adhere to form a cake when strewn on a hot plate. These cakes keep fairly well at sea, though Montaigne found the sample he tasted in France rather insipid, and the first expeditions to Mexico had to rely upon cassava and bacon, *cazabi y tocinos,* until they learned how to dress maize and had recruited Mexican women to follow the camp and bake *tortillas.* These excellent pancakes have to be made from dough made by rubbing soaked corn on a flat stone. Though elastic enough to serve for napkins and trenchers they are savory only when freshly made. In recounting the horrors which followed the defeat of the *noche triste,* Bernal Diaz does not forget the hardship of eating stale *tortillas* after the Indian women had deserted.

The conquest of Peru involved much greater hardships by reason of its greater distance from the base of supplies at Panama. The wretched band who remained with Pizarro while Almagro sought relief, gleaned only scanty sustenance from shell-fish and had to fall back on salt and bitter fruit of the interminable man-

grove swamps which border the coast north of the equator. The fertile valleys of Peru abounded in corn and beans, cassava and yams, and the native custom of drying all sorts of fruits and roots supplied a variety of portable foods. Moreover, all sorts of Spanish fruits were soon naturalized in the irrigated gardens, which the native cultivators, hemmed in by the sea and the desert, had to work for the benefit of their conquerors. Those Indians who dwelt in the wet regions of the tropics might always escape that obligation by taking to the jungle, and there the invaders often starved. The grape flourished in Peru and Chile, and the fame of their strong wines and brandies had something to do with the zeal of the buccaneers to capture towns and ships in the South Seas. These thirsty rovers often reveled in the capture of a prize laden with thousands of jars, each of which held seven or eight gallons of strong Pisco wine or raw brandy. These deadly liquors were excluded from Guatemala by Spanish law, but the pirates welcomed such spoil, finding the jars convenient for holding water after the liquor had all been drunk out.

North America had fewer agricultural products outside the tropics, though corn, beans, and squashes grew as far north as Canada wherever there was a settled population. On the other hand, there was no lack of game and fish, and the climate encouraged hunting. Thus Cartier in the Gulf of St. Lawrence loaded his boats with fat sea-birds, picking up guillemots by the ton and salting them for sea-stores. Upon entering the great river he found stores of food in the long houses of the Indians, corn and beans, smoked fish and eels, all neatly packed in baskets. These Frenchmen found the Indians unwilling to sell their stores and reported them stingy with their victuals. Yet they taught the strangers the rudiments of American cookery—how to bake corn bread between hot stones and how to blend beans, corn, and squash into a savory porridge, since known as succotash.

The New England pilgrims saved the lives of the remnant who survived the first winter by consuming part of a similar hoard of Indian corn and planting the rest according to native husbandry with a fish buried in each hill of corn. The standard of luxury in the second generation of settlers in Massachusetts appears in the list of presents forwarded in the hope of securing the favor of Charles II after the Restoration: besides several thousand choice codfish, there were certain barrels of cranberries and of "extra

good samp." Whether the Court liked hominy and the rest of these rustic dainties we are not informed, but Mr. Pepys declared that the Navy could not have put to sea to fight the Dutch had not the men of New England added a shipload of spars to their bounty. Of course the King disregarded the terms which the Puritans proposed in connection with their gift—a course in which history is bound to justify him—but he might have found a good word for samp and cranberries.

The Spaniards were not tempted to extend their domain to include the land where these were accounted as luxuries. Even in Florida the soldiers complained of hunger and urged that they might be sent to Peru. Melendez reported that he had left stores enough at St. Augustine to give each of them a pound of biscuit per day with occasional rations of meat, oil, and *garbanzos*.

The Antilles to which the soldiers who had removed the French from Florida for the most part deserted, abounded in luxuries even in their savage state, especially for Spaniards who had an allotment of "good Indians" to pay them tribute in the produce of the land. The means of subsistence having been multiplied by new crops and cattle, the immediate descendants of the conquerors could buy for a *real* two or three bushels of wheat, eight Spanish fowls, or three turkeys, but by 1557 these prices had increased tenfold and were nearly up to modern standards—the result of partial emancipation, according to conservative opinion.

The first Englishmen in Bermuda landed as castaways, but found food in abundance. They lived mostly on wild hogs—their one dog catching over a thousand—and were able to relieve a famine when they crossed to Virginia in a vessel built and provisioned at the islands. The permanent settlers were no worse off, as they found beans, peas, and pumpkins growing wild, turtles ready to be turned, and silly birds fluttering into their cabins and even into the fire, "with a strange lamentable noise as though they did bemoan us and bid us take, kill, and eat them." The hogs with which the Spaniards had stocked the islands must have grown scarce since Somers and his shipwrecked crew ate so many of them, as intending colonists were warned to avoid famine by bringing barrels of biscuit and of butter, besides vinegar, oil, and *aquavitæ*.

In spite of the advance in prices high living seems to have been the rule in Mexico during the seventeenth century. An English

friar out as a missionary to the Philippines about 1630 records the entertainment there provided "for our better encouragement to a second voyage at sea." Besides copious meals abounding in all sorts of fish, flesh, and fowl, sweetmeats—conserves of quinces and the like—were served with biscuits and chocolate at all hours of the day. To account for the appetite and digestion which overcame this profusion, the Spanish doctors put forth a theory of climatic influences, which produced "a fair show but little substance, applying this to meats, fruit, and men." Tempted perhaps by these Mexican feasts and theories Gage abandoned his mission and went to Central America, though the land journey reduced him to the debilitating Indian diet of "crabby lemons, water, and maize powder."

The northern margins of Mexico were regions of hunger for the European wanderer, as Cabeza de Vaca learned during his years of distress among the Indians of Texas. Most of the great company sent out to settle in Florida were slain, drowned, or starved in a series of misadventures, and the survivors were always on the verge of famine. The Texan tribes lived sometimes on fish, and at other seasons killed buffalo or deer, but their hunting involved incessant migration, often to deserts without fuel or water. Even in regions infested by clouds of mosquitoes, wood had to be carried to make smoke to drive them away. The savages were always lean and haggard except during the season of prickly pears. Then they pitched their camps among the cactus thickets and ate and drank incessantly, squeezing the juice from some of the fruits, pounding others into meal, and drying others like figs.

Voyagers crossing the Western Ocean before 1620 followed the Southern track, and many of them, especially the English, called at Dominica for refreshment—a compendious phrase everything from a chance to wash clothing and fill water-casks to traffic with the Caribs for fish and fruit. These Indians were never conquered by the Spaniards, and for the sake of political intrigue, the French and English allowed them a nominal independence until 1796. They have been called the first buccaneers, and whether the title refers to their manner of curing meat or to their practice of maritime piracy, they have some claim to it. Foreigners learned to follow suit, however, adopting their canoes and hammocks as well as both forms of buccaneering.

Their *boucan* or barbecue was a rack or table of sticks under which a slow fire was built to smoke and dry flesh or fish. Though the process was slow they used hardly any other method of cooking meats, and were thus provided with sea-stores. They consumed much fruit and also made cassava bread, which a Frenchman, sick of Carib diet, declared to be the only clean thing they ever ate. As for fruits, he said, they rather drank than ate them, heating and mashing them to induce fermentation and thus supplying themselves with intoxicants. They were fond of red pepper, of course, and they had a hot sauce made of the poisonous juice of the cassava root and the fat of land-crabs. This mixture they called *taumali,* and applied indiscriminately to all sorts of viands.

The Spaniards unwittingly promoted the establishment of buccaneers and other interlopers in the West Indies by stocking them with wild cattle. The cessation of gold mining and the destruction of the natives left islands like Hayti and Jamaica, capable of supporting an active population, without the restraints and delays of industrial organization. Thus Cromwell's shattered and sickly army, repulsed from the city of Santo Domingo and forced "to find food without fighting," drifted to Jamaica and founded the tropical empire of Great Britain, while the French colony of Hayti was a growth from the camps of cattle-hunting poachers.

The soldiers who were sent ashore to shoot cattle in the woods grew sick or lazy, and after the stock got wild, starved in the midst of plenty. Sailors did better, especially if their ships happened to have dogs, and they could go to the Caymanes for turtle. But only a remnant of the conquerors of Jamaica lived long enough to become acclimated.

Their successors, the buccaneers, at least knew how to cure meat, a simple process in a dry country but less easy in a land of tropical humidity. Beef cut into long strips, lightly rubbed with salt, and dried in the sun will stand a sea voyage with less loss of nutritive elements than corned beef barrelled in brine. Therefore *tasajo* and *charqui* are still staple exports from Buenos Ayres to Havana, for instance. But the *boucan* had to be sheltered, and the heat and smoke of a slow fire were employed to cure the superficial layer of the meat. Lean pork cut into long strips half an inch thick, salted, and smoked, was sweeter and more delicate than any other preparation of pork, and was a favorite article for buc-

caneering voyages. This savory bacon sold for $3 a hundred weight for a while, but the price had doubled by 1700. The flesh of turtle and manati was preserved in the same fashion and these were stewed with garlic by Spanish sailors, who compared the flesh of the manati when fresh to fine veal—a comparison which led an early Italian voyager to declare that the Spaniards were too hungry to notice what they were eating or else they had never tasted veal. Yet the later buccaneers liked manati and consumed great numbers of these sea-cows, which were quite helpless when assailed by the Mosquito Indians whom the pirates employed as strikers. In many of their West Indian "lurking holes" the manati was as important part of their food supply as the turtle.

Voyages to the Antilles or the Spanish Main were only a partial initiation to the privations of the sea as revealed to the intrepid discoverers of the Strait of Magellan and the South Seas. The first to pass the strait seem to have had better fortune than many later voyagers. Pigafetta, the chronicler of the voyage of 1521, tells of finding harbors only a few miles apart along the strait, each of them abounding in wood and water, sardines and shell-fish, and pot-herbs, sweet and bitter; no better strait anywhere, thinks the Italian explorer. Yet it is evident that no sea-stores were provided, since Magellan warned his people that he meant to keep them at sea until they had eaten the raw-hide chafing-gear from the yards, a grim threat which was soon verified. Biscuit they had, but it was pulverized by worms and defiled by mice, and it needed some resolution to consume it, though neither sort of vermin was spared after famine set in. Some relief was found in the Philippines, where fowls and pigs, rice and yams, could be obtained by trading with the natives or forcing them to pay tribute to the King of Spain. But privations lasted as long as the voyage, and only eighteen men completed the circumnavigation and got home to Spain.

The second expedition through the straits, that of Loaysa in 1525, was unlucky throughout, and its minor hardships were forgotten in the story of its tragic termination. Yet we find it noted that while the ships lay in a Patagonian harbor before attempting the strait an offer of fifty ducats, calculated as equivalent to a thousand in the spice trade, was made for the last pair of fowls left alive, and the owner refused to sell because the hen still laid fresh eggs of inestimable value for the sick.

Though Drake carried only a single vessel and a remnant of her crew back to England in 1580, his company were never reduced to the misery which Magellan's men had to endure. Yet Drake was notoriously a "bad provider" to the end of his naval career. Setting out for a voyage to the Pacific, his crews had to begin foraging on the African coast and among the Cape de Verde Islands, where they got little but water and wine. South of the Rio de la Plata they lived mostly on Patagonian diet, seals, "wholesome but not pleasant," dried ostriches from Indian storehouses, and penguins fat as English geese. In the strait 3,000 were taken and salted down on a single islet. But the *Golden Hind* ran short of stores again before a Chilean settlement could be pillaged, and here the foragers had to fight for their lives. From Valparaiso northward there was no danger of famine, and the ship of gold, the famous *Cacafuego,* yielded provisions as well as treasure and equipped her captor for a voyage across the Pacific.

Cavendish, who followed Drake's track six years later, had more hazards and adventures to encounter in his search for spoil and supply. He began by seeking infection at Sierra Leone and among the African islands, cruised without reward on the coast of Brazil, and got his first relief in Patagonia. Port Desire in latitude 48° south, was more generous than the tropics, yielding "wonderful great store of seals" and an island full of gulls and puffins. The flesh of young seals was "hardly to be known from lamb or mutton," and the fowls also were very good. Within the strait the company lived for a month "altogether on mussels, limpets, and birds." They were warned, however, that the change of seasons might cut off such supplies, since they saw—and abandoned to their fate—the last remnant of the colonists sent out to guard the strait and condemned to starve on its inhospitable shores.

One of the Spanish ambassadors at Elizabeth's court had predicted that Englishmen could never trade beyond the strait because they would have to be fully laden with provisions, "considering how these Englishmen eat," and hence would be unable to carry merchandize. The resources of the strait, scanty as they were, helped to defeat this calculation and in time gave this route a higher reputation than it deserved. Even Captain Cook thought that the refreshment to be obtained in the strait might prevent

scurvy, and thus compensate navigators for giving up the obvious nautical advantages of the sailing route via Cape Horn. This opinion related only to passages made during the Antarctic summer, and it failed to convince the merchant marine of any country.

When we consider the economic resources of the Strait of Magellan in detail their importance diminishes. The only fruit worthy of mention is the huckleberry, of which there are many varieties, and the wild celery seems to be the only pot-herb of any value. These are doubtless anti-scorbutics, but their nutritive value is insignificant. Fish are by no means abundant within the strait, and the natives wander from ocean to ocean in search of seals and whales. Sea birds swarm according to season, but the only perennial food supply is that obtained from the shore between high and low water. The Spaniards have a verb, *mariscar*, for this dreary employment of gathering shell-fish, but Sarmiento's colonists starved as soon as they had exhausted the accessible supply. The infinitesimal oysters which Korean women still gather show the inadequacy of such resources for supplying the needs of seamen.

The voyage which Cavendish attempted in 1591 showed the dangers of sailing for the Pacific at the wrong season and with a short stock of provisions. He sought supplies at Santos in Brazil in January, but through lack of discipline and energy his crew allowed the natives to hide their stores in the woods, and the ships sailed without provisions. Entering the strait in April, Cavendish encountered intolerable storms and was forced to return to Brazil, whence a few of his company got home in distress, having lost their general and most of the crew by scurvy or starvation. He had twice marooned his invalids during this dreadful voyage, and perhaps had little right to complain of mutiny and desertion as he did in his last letters. His consort, commanded by John Davis, the Navigator, wintered in Port Desire from May to August, and then returned to the strait. Upon going into port the crew saved their lives by gathering mussels at an extreme low tide, and smelts were taken with pin hooks. In the strait they salted twenty casks of seals, but the September gales drove them back from the Pacific, and they too returned to Brazil. The master had gone round the world with Cavendish, and he urged the continuance of the voyage in the Pacific, promising a supply of penguins at some island near the strait, wheat, pork, and roots at the island of

Santa Maria, and the chance of taking stores in prizes on the coasts of Chile and Peru. Finally he warned his comrades that the attempt to return left them nothing to hope for but death. Obviously the fate of the expedition depended altogether upon the chance of securing supplies, but with hunger arrayed against foresight the desperate counsel was bound to prevail.

Before running out into the Atlantic, the crew strove to cure penguins enough to avoid starvation. Salt was made at Port Desire, and no less than 14,000 birds were cured before December 22. The fare in port included eggs, penguins, young seals, and young gulls, besides an herb they called scurvy-grass—probably wild celery—which they fried with eggs, using train oil instead of butter. They were all sound when they left Patagonia, but Brazil yielded them nothing in the way of sea-stores, not even cassava bread, since the Portuguese ate the roots simply boiled or roasted.

When they sailed from Brazil there was not much left to live on except the unsavory penguins. The original allowance had been five birds for four men daily, with an occasional spoonful of oil or ounce of meal, and at that rate they should have lasted six months. The cutting off of a large foraging party in Brazil and the mortality which soon overtook the rest might have helped out this estimate had not the penguins become infested with worms, horrible vermin an inch long and capable of biting anything except iron. These nibbled at the planks of the ship, bit the sailors, and made sleep impossible. A malignant form of scurvy carried off most of the crew, and Davis was the only man in health when the coast of Ireland was sighted. Here he ran the ship ashore and landed the sixteen wretched men who survived.

After this miserable tale it is a relief to peruse the dietetic notes of Richard Hawkins, who entered the Pacific in 1594, and came to grief in battle off the coast of Peru. He gave much thought to matters of diet and cookery, and arrived at sound modern views in regard to the cause of scurvy. In Brazil he found the cassava flour, *farinha de pao*, an excellent material for pancakes; fried in lard, butter, or oil and strewn with sugar these were "meat that our men desired above any that was in the ship." He bought the thin, hard sheets of cassava bread also, and liked the kind made with chocolate, a sort of Brazilian spice-

cake. The Portuguese ate the boiled cassava root with molasses, and the Indians had learned to like it so. The English sailors found that it would make a kind of hasty pudding, which they called burgoo. Gannets boiled with pickled pork and thickened with oatmeal made "reasonable pottage," and Hawkins had these birds reserved for the sick. Fur seals lost something of their rank flavor when split, salted, soaked, and pressed, and might then be resalted and packed in beef barrels for two months' keeping. Young gulls were to Hawkins "the delicatest food I have eaten in all my life." With so cheerful and diligent a caterer the passage of the strait must have lost many of its hardships. The verdict on the fur seal as an article of diet will seem to most who have tasted its flesh somewhat distorted by official optimism.

The pilot who promised to find food in the Chilean archipelago for Davis and his company was justified by experience. Chiloe, Mocha, and Santa Maria were good supply stations for the products of the temperate zone; wheat, barley, and potatoes in bales ready for shipment might often be brought off by men hungry enough to fight for refreshment. Wild cattle and hogs were to be found on some of these islands, and there was a chance of fowls and fruit.

But of all the Pacific islands none holds so high a place in the annals of sea-faring diet as Juan Fernandez. The earliest account of its resources was given by Dampier, who visited the island as a pirate in 1681 and 1684 and as a privateer in 1704 and 1709; and it is to be regretted that they are best known from the disfigured version incorporated in Robinson Crusoe by De Foe. The most thorough test of the habitability of this island appears in the narratives of two men who were marooned on the island during the age of the buccaneers. The more famous of these was Alexander Selkirk, but the Mosquito Indian who preceded him showed a higher degree of woodcraft and self-reliance. He was one of the hunters for Watling's crew of pirates when he was left ashore by accident with a knife and a gun as his sole equipment. The knife was soon turned into a saw, and the gun-barrel was made to furnish material for a set of spear-heads, fish-hooks, and knives by which he was enabled to kill and utilize all the game and fish which resorted to the island. With hospitable foresight he killed three goats and cooked them with palm cabbage as soon as he sighted English ships in the offing. Spaniards had

visited the island during his stay and he had exercised his savage ingenuity in hiding from them, though unlike Crusoe, he did not build a fortress to hide in. Unlike Selkirk he drew most of his sustenance from the sea, but he took his share of all the products of the island, his tribal customs being cheerfully omnivorous.

Selkirk was more amply equipped, as his landing was deliberately planned, and as a civilized man, he was more scrupulous in the matter of diet. He could not eat fish, for instance, without salt, and he was unable to prepare that condiment. But he derived much comfort from the excellent crawfish, and became a bold and skillful hunter of goats, running them down by swiftness of foot on the steep slopes of the hills. While developing his athletic powers he did not neglect study, and completely mastered his epitome of navigation besides giving much time to the Bible. He brought clothes and bedding ashore, and wore linen shirts to the end of his five years of solitude, though he made outer garments of goatskin when he needed them. Shoes he had the good sense to abandon, and his feet were hardened for climbing. For the sake of concealment his lodgings were built in trees, lining them with skins to keep out wind and rain. He had a cooking camp at a reasonable distance from his dwelling, and altogether lived in a decent and wholesome fashion.

With these narratives in his possession De Foe wrote the first novel of adventure. Though he landed his hero on the island of Tobago, he dealt with the climate and products of Juan Fernandez, but without any comprehension of the simple rules of hygiene and diet necessary to preserve life. Crusoe had a year's stock of provisions, bread, rice, and cheese, to say nothing of rum to outlast a generation, even though he could hardly take a stroll without loading himself with flasks. With his surplus tools and stores Crusoe had to work as a shopman to keep them in order, and he seems to have had little relish for any food not prepared for the counter of a baker or grocer. Though he remained a bad carpenter to the end, he became a fair hand at pastry, and he admired the results of his efforts as a tailor. Goats' milk had to be turned into cheese, and wheat baked into bread to satisfy his longing for commonplace superfluities. Even when he resolved to rescue the Spanish crew held captive by the Caribs or other cannibals he kept them waiting until he could raise wheat enough to keep them for a whole year. As for clothing, he defied

the climate by wearing complete suits of goat skin, and he lost no time in subduing Friday to his absurd standard of propriety, though he admitted the discomfort of goat skin trousers to the natural man. Turtles, fish, and birds meant nothing to a man so resolute in living the life of a shop-keeper, and no marooned or shipwrecked mariner could ever thrive on the maxims of Robinson Crusoe.

The capacity of Juan Fernandez for supplying both sea-stores and refreshments was most thoroughly tested in 1720 by Captain Shelvocke, a naval officer employed as a privateer and degenerating toward piracy, who was wrecked on the island with a refractory crew of English sailors. A little bread, beef, and cassava meal was saved, shelters were erected, and there was tolerable comfort at first, at least "in the evening around a great fire, roasting craw-fish in the embers." But the Captain was resolved to build a vessel from the timbers of the wreck, and he had to find stores to enable him to continue his voyage. Goats were now wild; there were too many cats about the camps; but fish and seals were the most abundant articles of food. These had to be rejected as sea-stores on account of the scarcity of salt, and conger eels were caught as the principal stock for the voyage. They could be cured by smoke after being split and lightly salted, and 2300 of them were packed for the voyage. Their average weight was only a pound, and they had to be fried in seal-oil, of which sixty gallons were provided. No cats were taken on board, though some who had been able to stomach their flesh reported that one meal of it gave more "substantial relief" than four or five of fish. During the five months spent on the island, living without bread or salt, there was not a single case of illness, and it is hard to blame the deserters who absconded before Shelvocke put to sea.

The forty men who sailed with their captain were huddled together and forced to lie on the bundles of eels, "with nothing to defend us from their abominable stench," Shelvocke complained. The water supply was scanty and hard to come at; there was only one cooking place; and the men lived in "a continual noise of frying from morning to night" and in perpetual quarrels, "contending for the frying-pan." Though they met and fought a Spanish vessel on the fifth day out from Juan Fernandez, they got no relief until they landed at Iquique three weeks later. In

spite of their hungry desperation, their little cannon charged with bolts and pebbles failed to bring the Spanish ship to terms. Finally a vessel of 200 tons was surprised at anchor off Pisco, and they were able to abandon the wretched bark built at Juan Fernandez.

Thereafter foraging along the coast was tolerably successful; corn and beans, dried beef and salt fish, were the staples, but they sometimes blundered upon luxuries, such as fruit, fowls, and eggs. Near Quibo to the westward of Panama they found an island *hacienda* well-stocked with cattle and hogs. After a breakfast of hot cakes and milk they set to work to cure beef in thin strips lightly salted—only five pounds of salt to a hundredweight of meat—and carried off a good supply. Nevertheless they again encountered scarcity, having no stores but beans until the Juan Fernandez eels were recalled to memory. These were brought from the hold and served out to the crew, though they had "lain soaking and rotting in the bilge water" during months of tropical cruising. After this nauseous experience it is not surprising to learn that the crew insisted upon taking prizes after due notice of a treaty of peace between England and Spain or that Shelvocke consented to this piracy, which was rewarded by "a twelvemonth's provision of bread, flour, sugar, and sweetmeats," the latter including marmalades, preserved peaches, grapes, and limes from Peru. The prizes also supplied negroes enough to double the force of the piratical crew.

Among the "great variety of dangers and distresses" which Shelvocke describes, those due to the overladen pinnace and the unsavory eels were not the least memorable. Raleigh had a similar experience in ascending the Orinoco in 1596 with a hundred men in five small boats" and their victuals for a month in the same, being all driven to lie in the rain and weather, in the open air, in the burning sun, and upon the hard boards, and to dress our meat and to carry all manner of furniture in them, wherewith they were so pestered and unsavory, that what with the victuals being mostly fish, with the wet clothes of so many men thrust together and the heat of the sun, I will undertake there was never any prison in England that could be found more unsavory and unwholesome, especially to myself, who had for many years been dieted and cared for in a sort far differing." This is too long and breathless a complaint to be coupled with the assur-

ance that not a man was made ill after all, and the personal reference helps to explain why history has at last decided to commemorate Raleigh as a courtier and projector rather than a seaman or an explorer.

The reputation of Juan Fernandez owes more, perhaps, to the classical narrative of Anson's voyage in 1740 than to any other document. Never were ships in a lower stage of hygiene than the *Centurion* and her consorts in the South Seas. At St. Catherine's island on the coast of Brazil an effort had been made for "correcting the noisome stench on board and destroying the vermin" by landing the crew and scraping, smoking, and scouring with vinegar between decks. Fruit, onions, potatoes, and beef of bad quality were bought for daily use, but no live stock or other stores for the voyage was obtainable. During a ten days' stay at Port St. Julian little use seems to have been made of Patagonian produce, and Cape Horn was rounded too late in the year and under unfavorable conditions for health. The defective charts with which Anson was provided prevented him from seeking relief in the Chilean archipelago, and restricted his choice of a relief station to Juan Fernandez, but it took him almost two months to make the island after he got clear of the coast of Tierra del Fuego.

When the landfall was made in June only eight seamen out of a crew of nearly 500 were fit for duty, and the officers and their servants—doubtless the best-fed men in the ship—had to work the ship in approaching the anchorage. As soon as the anchor was down a boat was sent ashore to reconnoiter, and this brought off a favorable report and a load of seals and grass. No time was lost in clearing the decks of the surviving victims of scurvy, and some hundreds were soon encamped ashore. Many died during the disembarkation, and the death-rate did not fall below half-a-dozen a day for nearly a fortnight. This was disappointing, since immediate results had been expected from their removal from decks which had suffered from the inevitable "great relaxation in the article of cleanliness," to which the clerical chronicler delicately refers.

There was no lack of anti-scorbutic vegetables about the camp; water-cress, purslain, and sorrel grew self-sown; turnips and radishes—which the seamen classed together and used only as greens—had been planted in the clearings and now produced

regular crops, though the roots were coarse and stringy. Anson sought to increase the variety of these garden products, "for the accommodation of his countrymen who shall hereafter touch here," by planting seeds and stones, and the peaches mentioned by many voyagers may date from his visit. Doubtless his gardens helped Spaniards as well as Englishmen, however narrow his intention may have been. The goats had grown even scarcer than in Shelvocke's time, dogs having been turned adrift to exterminate them to the disadvantage of the buccaneering trade. The cats had also grown scarce. Anson's men rarely got more than one goat a day, but they could have all the seals and sea-lions they wanted, though they only condescended to eat such flesh when they grew tired of fish. These last were the staple diet, with craw-fish running to eight or nine pounds as a special luxury. One of the last vessels to join the flagship was sighted several weeks before she was able to make the anchorage, and her crew must have perished had not Anson sent boats to assist and supply them with water, fish, and vegetables. As it was, three-fourths of her crew had been committed to the deep before she came to anchor.

The crew of the *Wager,* which was wrecked on one of the Chilean islands, had to endure even greater hardships than their comrades who reached Juan Fernandez. When the ship struck the spirit-room was broken open, and many drunken men were lost with the ship. Few stores were saved, but with fish bought from roving Indians and shell-fish gathered from the rocks the men who got ashore were able to support life. Discipline could not be maintained, however, and the larger part of the crew made mutinous preparations for a voyage to Brazil. Sailing in October, 1741, they reached Rio de Janeiro in January, having lost fifty out of the company of eighty. Of the twenty who remained with the captain, only four survived to reach a Spanish settlement a year after the shipwreck. This tragic story illustrates the helplessness of men ignorant of the primitive arts of hunting and fishing and reduced to the resources of Patagonia.

By September Commodore Anson was ready to begin his cruise for the destruction of Spanish commerce with two ships, carrying 335 men out of the force of 961 who had sailed from England. The Admiralty's plan of recruiting this force contributed as much to this mortality as the defects of its method of supply. Invalids

from Chelsea Hospital and marines, freshly recruited and absolutely untrained, furnished 500 of the victims. For supplying the wants of the squadron two agent-victuallers had been appointed and furnished with trade goods to the value of £15,000 to exchange for provisions. Most of this stock was lost in the *Wager*, and a quantity of stuff carried round the world had to be sold in England for a fourth of its cost. Yet this trading scheme had been regarded as promising almost as much profit as might be won by attacking the enemy's commerce.

Before leaving Juan Fernandez a large part of the stock of provisions, bread, rice, and groats, had to be condemned, and the only new supply laid in consisted of salt fish, which proved very unwholesome, and a few casks of sea-lion oil. Payta was the next relief station, but only a few hogs and hens were brought off when the town was pillaged and burned in November, 1741, and the failure to find sea-stores was by no means compensated by the seizure of a boatload of silver coins and church plate. At Quibo Anson's men learned to live on tropical products, and green turtle became a staple food for several months. These were readily taken at sea as well as in port, but it required vigorous measures to induce the slaves, negroes and Indians who had been taken from prizes and kept to assist in the ship's work, to accept this kind of rations, though they came to be fond of it before long. Little else could be picked up on the Mexican coast, and the boats had to cruise for turtle even when the ships lay in port.

Many landings were made to find water for the coming cruise, though it was reported that the Manila galleons relied on the heavy rains of the tropics to furnish their supply, husbanding the water by spreading mats to catch it and split bamboo conductors to lead it into jars. One of the *Centurion's* boats was adrift without supplies for some weeks on the Mexican coast, unable to land on account of the surf and reduced to the last extremity of thirst. Relief was finally obtained by a shower, and their breakers were filled by spreading the sails as awnings and weighting them with bullets to hold the rain water.

In spite of the advice contained in the narratives of his predecessors, the buccaneers, Anson made no effort to recruit at any of the favorite outlying islands of the eastern Pacific. Puna, Gorgona, and Plata were tropical islands and no better or worse than Quibo, but the Galapagos, Cocos, and Tres Marias had

special climatic conditions and products which had attracted many companies of the buccaneers. The Galapagos have a sufficiently uniform climate, as they lie directly on the equator, and a reasonable rainfall, though many who sought water there were unable to fill their casks. The buccaneers must have been more successful, since they often spent months here, and even established provision depots on the islands. In 1684, when Dampier and Cowley were pirates in the South Sea, a stock of 1500 sacks of flour and a quantity of sweetmeats were landed here. The islands were not rich in vegetable products until successive colonies had attempted and abandoned agricultural settlements. In 1892, however, there was a flourishing *hacienda* on Chatham Island, and Charles Island, then uninhabited, had productive orchards of tropical fruits and large herds of wild cattle, hogs, and donkeys. The buccaneers sought animal food mostly, and these islands offered them certain special luxuries. Besides the rock-fish and green turtle which their boats might catch, they were always sure of plenty of iguanas, most delicate food for those who had outgrown prejudice against lizards, and the giant tortoise from which the group takes its name. These creatures were helpless and easily taken; their flavor was excellent, their weight might run to several hundred pounds, and they could be carried on long voyages without requiring to be cured as sea-stores or fed as live-stock. Birds in great variety—flamingoes were still to be shot a few years ago—haunted the Galapagos, and doves and the like were so tame that they could be picked up by hand.

Cocos Island belongs to the damp region of the tropics and is covered with rank vegetation accordingly. In a state of nature fish and turtle must have been its chief supplies, but pumpkins and pigs were long since naturalized in its woods, and it has always been a convenient watering place. The group of the Tres Marias had a more arid climate of the Mexican type and was not recommended for watering. Seals, turtle, fish and birds were at hand, and the Mosquito Indian strikers kept the ships of the buccaneers supplied with fresh food. Water and sea-stores had to be brought from the main, and expeditions to the *haciendas* lying far inland were hazardous, and many lives were lost in the search for corn and beef. Consequently most of the rovers who crossed the Pacific ran short of provisions before reaching the Ladrones.

Before considering the hardships of this passage it may be well to compare the experience of Commodore Porter in the *Essex* in 1813 with that of his fore-runners. His outward voyage somewhat resembles that of Anson, since he tried to obtain supplies at St. Catherine's and found the Brazilian prices extortionate. These were mitigated by warning all boats away from the ship unless they would give in exchange for a dollar one turkey, or three fowls, or nine watermelons. Sailing without any considerable addition to his stock, Porter found his supply for the Cape Horn voyage to include 21,763 pounds of bread, 184 barrels of beef, 114 barrels of pork, and 1,741 gallons of spirits. This meant diminished rations, and the crew of the *Essex* accepted a two-thirds' allowance of beef and pork—"six upon four," in old sea-faring speech—but offered a self-denying protest when their grog suffered the like retrenchment. Porter felt that he could not permit them to refuse their rum, since a sudden privation "would cause sickness and dejection among them," and he saved the situation by giving notice that grog would be served as usual and the tub upset fifteen minutes later. Having only 201 gallons of vinegar, he resolved to disregard the old custom and add it to the ration instead of expending it in fumigating and scrubbing the ship. Having learned from Cook to distrust the fat of salt meat, he forbade the frying of hard bread in slush from the galley.

With these precautions the crew recovered from the dysentery contracted in Brazil and rounded Cape Horn without much loss of life. One man died to illustrate the fact that the methods of recruiting were still those of the eighteenth century; he was sixty-five years old and suffering from a chronic disease of the lungs, but he was carried to sea to die because he was a handy man for tending the live-stock. As the ship's rats and a number of Brazilian monkeys were devoured during the run, it may be assumed that there were few cattle on board. Upon arriving in the Pacific, Porter had to consider where relief might be found. He had resolved to avoid towns in order to keep his movements secret, and he was thus cut off from the ordinary commercial methods of supply, his plan being to replenish his stores from prizes taken at sea.

His first landing was made at the island of Mocha, a favorite provision ground in the sixteenth century, where his whole company landed to shoot wild cattle. An officer had the misfortune

to shoot one of the seamen, and the expedition was far from being profitable. Hogs and horses were shot, however, and we are assured that the latter furnished the better meat. Foraging without organization was found to be both hazardous and unproductive.

During her successful search for British whalers the *Essex* made the Galapagos her principal supply station. The prizes were well-stocked with sea-stores, but the special products of the islands were indispensable. The boats could bring in a daily harvest of green turtle—loggerheads being altogether despised—and excellent fish, while the volcanic rocks swarmed with iguanas in masses covering whole half-acres, and the huge tortoises were by no means rare. Captain John Macy of Nantucket had posted a notice that he had recently carried off 250 "turpen," and the English prizes yielded 800 to the *Essex*. One ship threw overboard fifty, which were readily picked up afloat. There was never any difficulty in capturing these monsters, as they were mild in temper and quite helpless when turned. At James Island the *Essex* took fourteen tons of them for sea-stores, but found them inferior to those previously consumed, belonging to a different species,—a fact which Darwin noted from Porter's journal as confirming the surprising variability of species in this group of islands by which he was led to adopt the theory of evolution after an examination of his own collections in the Galapagos. At its best the flesh of the great tortoise was a delicate food; "the finest green turtle is no more to be compared with them than the coarsest beef to the finest veal," Porter assures us, while the fat is superior to the best olive oil.

The *Essex* stowed her tortoises in the hold—after a few days' fasting—and it was supposed that they would keep for eighteen months without food or water. Another destroyer of commerce who followed Porter into the Pacific in 1815, the Irish adventurer whom the Argentines commemorate as the Almirante Brown, sailed in his own ship to attack Guayaquil and went to the Galapagos in a state of destitution after his attack failed. Abingdon Island yielded him seventy tortoises, and their average weight was about 150 pounds. With this supply he sailed for the Atlantic and killed his last tortoise off Cape Horn. A casual relief from an English vessel enabled him to reach the West Indies.

At Tumbez on the South American coast the *Essex* got a

scanty store of beef and liquor, but no regular allowance of liquor could be issued until two puncheons of Jamaica rum were found in an English prize. Whether because the rum was excessively strong or because the long season of enforced sobriety had weakened the men's heads some scores of them had to go drunk to their hammocks after the first issue of grog.

A run to the Marquesas Islands brought them other opportunities for indulgence of a more romantic nature. The *Essex* found a harbor at Nukahiva, an abundant supply of water, plenty of bread-fruit, bananas, and cocoa-nuts, and so many hogs that no salt provisions were consumed for several months. Like Magellan, except that he had better fortune, Porter joined in tribal warfare and levied tribute of provisions from both enemies and allies, and he annexed islands like an Elizabethan privateer, or at least proclaimed a protectorate. His political zeal left no permanent result, but it would be interesting to learn the fate of the tortoises from the Galapagos which were turned loose to stock the Marquesas. The *Essex* sailed for the South American coast with her decks full of hogs and a supply of cocoa-nuts and copra, which the natives recommended as food, leaving a garrison to hold the little fort amidst the "demoralizing pleasures" of Nukahiva. The future of this little company was hardly less tragic than that of those who sailed in the *Essex*, though decidedly less glorious.

Returning to inquire into the commissariat of the buccaneers who undertook the voyage across the Pacific, it appears that the *Cygnet* in which Dampier sailed in 1684 had less than a pint of corn for each man's daily ration, and served only one meal a day, consisting of eight or ten spoonsful of hasty pudding. This must have been made as a thin gruel, since it is stated that many went without drinking for ten days or longer while on this diet. Naturally there was much grumbling in sailing 7,300 miles, and cannibalism was under discussion before they arrived at Guam. Dampier tells us that he grew very lean but was otherwise benefited in health. Captain Eaton's crew were less fortunate in crossing from Gorgona to Guam, "no man being free from scurvy and most of us in a consuming condition," Cowley reports. Woodes Rogers in 1710 had to reduce rations, but there was little hunger and less disease after this reduction. Shelvocke in 1721 had, as always, evil fortune; he chose to account for the digestive

troubles which afflicted his people by attributing them to "the quantities of sweetmeats they were continually devouring, together with the dried beef half-devoured with ants, cockroaches, and other vermin, which was their daily ration." This bill of fare shows that they got their stores from a Spanish prize, the unwholesome sweetmeat being probably guava paste or marmalade. The captain had no control over the issue of provisions, and the sweetmeats had been distributed as prize goods along with the wine and brandy taken by piracy.

Shelvocke had been distracted over the liquor supply ever since he sailed from England and parted company with his consort at the mouth of the Channel. Captain Clipperton neglected to take his share of the stock of liquors, and his crew were hardly to be persuaded to continue the voyage "without wine or brandy to keep up their spirits in that uncomfortable navigation" toward the Antarctic. The *Speedwell*, Shelvocke's ship, was crank with her excessive lading of casks, and carried sail badly. The *Success* got to Juan Fernandez ahead of her consort and landed her sick to restore them to health; "but the very thought of being without any cordial to comfort them dejected them excessively," so that all hands "were continually cursing Captain Shelvocke for running away with their liquors." A few months later they got a prize with 400 jars of wine and brandy on board, a most welcome refreshment.

Out of Shelvocke's superabundance no liquor was saved for the castaways of Juan Fernandez. While living on the rank flesh of seals, Shelvocke complains, "no food ever required a dram to digest it more than this, but we had not the least drop of anything spirituous."

Clipperton seems to have been reduced to like extremity, though when he lay at Cocos Island he opened his last cask of brandy and served out a daily dram. There was also a gallon of strong beer for each mess on New Year's Day, and thus with plenty of nourishing food and much ease, the crew recovered strength to take in wood and water. The captain must have had a private stock, since his future misfortunes were attributed to excessive drinking; "he was hardly ever quite cool or sober." At Guam in May, 1721, he had received a present of fresh provisions, palm wine, chocolate, and brandy, he tried to extort a ransom for a distinguished Spaniard whom he had captured at sea, by threatening

to demolish the houses, burn the shipping, and "do all the mischief he could in the Philippine Islands," though aware that peace had been concluded between England and Spain. The batteries opened fire, and the *Success* grounded in trying to escape from the harbor; the action lasted two days, and Captain Clipperton was so "overcome with liquor" that the officers put a Mr. Cook in command, the first mate having been already slain. The ship got to sea at last, and terminated her voyage in Amoy, the crew enforcing the distribution of the spoil and making the best of their way to England. Poor Clipperton died a week after landing in Ireland, of "a broken heart," according to the simple diagnosis of the age, but perhaps his sea-stock of liquors had its influence.

The buccaneers and privateers who resorted to Guam did not always find the Spanish authorities intractable. Dampier and Cowley were plain pirates, yet they report a reasonable traffic in provisions and some traces of official courtesy about 1685. Hogs were so abundant that the *Cygnet's* crew salted down fifty after a long revel in fresh pork. Bread-fruit was roasted daily and sent off with boat-loads of melons and cocoa-nuts. The captain got pickled mangoes and fish, besides rusk, rice, young pigs for roasting, and Manila tobacco, for which he paid with powder and shot, giving an astrolabe, a telescope, and a high-bred English dog as presents. But the governor took pains to warn the Manila galleon away from the island before his guests were aware of her approach. Captain Eaton had a similar traffic, and the authorities tried to secure his help in killing the natives, who happened to be in rebellion at that time. Woodes Rogers, with whom Dampier sailed as pilot in 1710, got supplies at Guam, "in a more plentiful manner and at a cheaper rate" than he had anticipated. The records of the island are said to show that the governor, Don Juan Antonio Pimental, was called to account for trading with the enemy, but cleared himself by showing that this traffic had enabled him to secure the restoration of the church-plate carried off from Guayaquil by Rogers and his oddly assorted company, which included Alexander Selkirk and Dr. Dover of the powders, as well as Dampier. Clipperton found a less complaisant governor; and Shelvocke ran through the Ladrones without attempting to relieve the sufferings of his wretched crew, making Macao his first port of call in the Far East.

Anson had only one ship left when he made his landfall in the Ladrones in August, 1742, and most of his people were again stricken with scurvy. He thought it unsafe to visit Guam with a helpless crew and therefore sought relief at Tinian, an island without any permanent inhabitants. By showing Spanish colors the *Centurion* decoyed the master of a Spanish coaster on board, and received most comforting information concerning the resources of Tinian: "There were an incredible number of cattle, hogs, and poultry running wild on the island, all of them excellent in their kind; . . . . . the woods produced sweet and sour oranges, lemons, limes, and cocoa-nuts." Bread-fruit was also abundant and even water was promised. The chaplain's descriptive powers responded to these attractions, and he has much to write of the "elegant and entertaining prospects" afforded by the lawns and groves of this island, "so exquisitely furnished with the conveniences of life, and so well adapted, not only to the subsistence, but also to the enjoyment of mankind." While admitting the lack of running water as impairing the park-like perfection of the views, and the inconvenient existence of flies, mosquitoes, and ticks, he insists upon the salubrity of the air and its power of "invigorating our appetite and digestion."

The sick were landed with much difficulty, twenty-one of them dying in the act, but the rest made a quick recovery and were able to be about in a week or so. The abundance of acid fruits doubtless contributed to this improvement, but the rest of the dietary regimé seems appalling to those familiar with recent opinions concerning the regimé for invalids in the tropics. But the chaplain assures us that the daily "beef breakfast" and the feasts which followed it, though "prodigious in quantity," caused neither repletion nor indigestion. Officers who had been spare and temperate eaters here suffered a sea-change, and "instead of one reasonable flesh-meal, they were now scarce satisfied with three." There was no wine or brandy in the camp, so the working-parties had to content themselves with the milk of cocoa-nuts, which kept them "very cool and orderly." Obviously sailors were more tractable when liquor was out of the way, but it does not seem to have been argued that the deprivation favored the restoration of their health.

Anson's people found the resources of Tinian adequate to the maintenance of this scale of diet to the end of their two months'

stay. No less than 10,000 cattle were feeding in the meadows, milk-white kine with black ears, for the most part, and these could be run down and captured even by over-fed Englishmen. Fowls were easily picked up, since they could only rise for one short flight. Hogs had to be hunted with dogs or shot. Yet with all this profusion, sea-stores were not at hand, as Anson convinced himself when the *Centurion* was driven from the anchorage and was not sighted for seventeen days. To find means for escaping from the island he had to refit a Spanish bark of forty tons, paying her bottom with a mixture of lime and tallow and raising her bulwarks for an ocean voyage. But the chief problem was to find her in stores. Tinian yielded no substitute for bread, there was no salt for curing beef and pork; the supply of jerked-beef captured was very scanty, and the only plan available required a raid on an island where rice was abundant. The reappearance of the ship prevented any attempt to test the value of these expedients, and the Commodore sailed for the coast of China, relying on his old stock of English provisions, after taking in fifty tons of water and stripping the groves of Tinian of all their oranges.

In 1765 Commodore Byron, who had failed to visit Tinian only because he was wrecked in the *Wager*, took another squadron round the world, passing through the Strait of Magellan and visiting the Ladrones. Though the squadron had touched at other islands no refreshments except cocoa-nuts had been brought off, and the ships were full of cases of scurvy, the Commodore himself being afflicted, before they sighted Tinian. With Anson's narrative as a guide the landing must have been cheerfully planned. The actual conditions were less agreeable; the rains were "violent and almost perpetual and the heat intense;" the camp was "infested by mosquitoes in the night and by flies in the day," to say nothing of ants, centipedes, and scorpions. The lawns of the chaplain's landscape were covered with reeds and saw-grass taller than men and alive with insects. But the bitterest comparison related to supplies. The water in the *Centurion's* wells was brackish as well as wormy. A hunting party got one bullock after three days and nights of toil and misery and saw the meat become fly-blown and otherwise intolerable long before they could drag the carcass to the camp. Poultry went wrong an hour after killing. Pork was the only serviceable flesh, but the hogs could not be taken until a negro of the company devised a system of snaring them.

It must be noted that, while Anson reached the island a little later in the season than Byron, the stay of both navigators included the month of September. The contradictions in their narratives must owe something to the literary instinct of the earlier chronicler and something to the critical temper of the later. Perhaps there was also some obscure personal hostility between the successive commanders. Byron, otherwise known as "Foul-Weather Jack," was ever at odds with the elements, and his famous grandson inherited a strange temperament.

All the archipelagos inhabited by tribes of the Malay stock seem to have been supplied with poultry and hogs before they were discovered by Europeans. The methods by which the progenitors of this live-stock were transported to the remoter groups of the Pacific in praus or out-rigger canoes would be interesting if they were not pre-historic and therefore inaccessible. Pigs and poultry were found in some of the most savage islands by the Spanish explorers of the sixteenth century, by Mendana in Santa Cruz and the New Hebrides, as well as in Tahiti and the Marquesas, and by Quiros in other islands. The latter founds his argument for colonies in the South Seas upon the expectation of sea-stores, lard and hams, vinegar and spices. There were roots which could be roasted to serve as bread, while beans and pumpkins would flourish, and scarcity of fish or fruit was unknown.

Captain Wallis, who visited Tahiti in the course of his voyage of circumnavigation (1766-1768), found it easy to buy fruit, fowls, and hogs to heal his crew of scurvy. Before a market could be opened the chiefs claimed a gift, but they were satisfied with hatchets and mirrors, and the stores were bought with nails and spikes. Unfortunately the market was disturbed and the standard of values upset by a "singular traffic" between the native women and the sailors. Not only did the price of hogs advance until a spike bought less than a nail had done at first, but the ship ran the risk of becoming unseaworthy by the drawing of her fastenings for the more licentious form of trade. A general restriction of liberty, and the flogging of such nail-thieves as could be detected, failed to restore discipline, while commercial honesty declined to the point of substituting strips of lead for the nails and spikes which were demanded by unlicensed bargainers.

Many explorers have commended Tahitian cookery, of which the method was essentially that of the clam-bake. After heating

the stone pavement of a cooking-pit, the fire was raked out, and a layer of palm-leaves was spread over the stones. Upon this the meats were spread, wrapped in plantain leaves, and packed in alternate layers of hot stones and embers. Small pigs were roasted whole, hogs in two packages. The heaped pit was thatched with palm-leaves and sealed with a layer of earth. The result, after a proper interval, was most appetizing, the meats being "extremely tender and full of gravy." It was carved with shell-knives or strips of bamboo, and served with a bowl of salt water and a liberal supply of fruit for each guest. A meal might include, according to Cook's narrative, two or three fish as big as a perch, three roasted bread-fruit, a dozen or more large bananas, and a quart or so of the custard made of bread-fruit and bananas crushed in a bowl with the milk of the cocoa-nut. Pigs were roasted for state occasions only, and foreigners as well as natives regarded their flesh as delicate food. They were fed on fruit and cocoa-nuts only, and could not be carried to sea in the explorers' ships, as they refused to eat the food offered them.

The dietetic adventures of voyagers in the North Pacific must be passed over more briefly than those of navigators in the South Sea. Animal food was abundant as far north as Bering Strait, though the supply varied with the season, and much skill might be required to support life. High powers of digestion were also needed by the native customs of devouring food raw—even such tough morsels as the flipper of a seal—and soaking everything in grease of rank flavor. These are the Eskimo fashions, while the Indians further south are more addicted to cookery, using hot stones for cooking in water-tight baskets blending the flavor of successive viands thereby. The fat of the candle-fish is one of the milder forms of concentrated food prepared in the north, and little crab-apples pickled in this oil are one of the few attempts to preserve a vegetable food. Cook found the bales of smoked sardines sold by the Indians of Vancouver Island desirable for sea-stores. In all these latitudes he dosed his ship's company with roots and herbs brewed into a compound which he called spruce-beer. In Unalaska he traded tobacco for dried salmon and sent his men ashore to pick berries. The big and helpless creature known as Steller's sea-cow was already scarce when Cook cruised in Bering Sea and soon became extinct under the pursuit of Russian explorers and their native purveyors. An animal of sluggish

habits and savory flesh has little chance in the struggle for existence. Seals are, perhaps, the chief staple of the northern supply, but no amount of fresh animal food enabled the Russians to avoid scurvy. Bering, the ablest of their explorers, died of that disease on the island that bears his name. A special danger of Alaskan waters is due to the fact that the mussels, the most accessible and not the least savory of shell-fish, are periodically apt to be poisonous, as the Russian cruisers learned under heavy penalties.

In the Philippines and the Indian Archipelago diet was subject to commercial conditions even in early days, and such staple articles as rice and sago, pigs and poultry offered few adventures in the way of diet. The ubiquitous Chinese trader had tricks of his own at every period. At Canton he loaded the ducks that Anson bought alive with ten ounces of gravel, and increased the weight of pigs by several pounds of water after a preliminary course of salt food and the adjustment of a surgical appliance. Magellan annexed Cebu to the Spanish crown and then made war on the natives because they failed to pay taxes in food-products. Cavendish got a generous supply by trade or gift from Capul and conceived that the natives paid tribute for the sake of becoming British subjects, and annexation was proclaimed accordingly. The gifts bestowed on his company in Java would have justified the annexation of the whole Indian Archipelago by the same line of reasoning.

The voyage of Captain Bligh from Tahiti to Timor in the open boat into which he and the loyal portion of his crew were thrust by the mutineers in 1788, was a remarkable undertaking. With a stock of provisions sufficient for five days at the regular allowance they were able to sail 3,600 miles in forty-seven days. This voyage was accomplished by rigid economy in the issue of provisions and diligence in searching for them along the barren shores of northern Australia. A landing at Tofoa near Tahiti gave the natives a chance to stone the castaways and added nothing to their supply. The stock for nineteen men consisted of 150 pounds of bread, 20 pounds of pork, 28 gallons of water, 3 bottles of wine, and 5 quarts of rum. The spirits doubtless proved of great value under the circumstances, though the strain of guarding them must have been incessant.

The regular cruising allowance for each meal, breakfast at 8 A. M., supper at sunset, was one twenty-fifth of a pound of bread

and a quarter of a pint of water, with the occasional addition of an ounce of pork or a tea-spoonful of rum. When a bird was caught it was dissected, and the portions were issued by lot—names being called by a man who could not see the corresponding portion. The first landing on an islet off the Australian coast was made a month after leaving Tofoa. With oysters from the rocks and a little pork and bread a stew was made, and a pint and a half of this pottage, sometimes varied by the addition of wild beans or palm cabbage, was the usual allowance ashore. Water was also found, and certain berries proved edible; there was a botanist in the company and his opinion concerning the nature of fruits and plants was much in demand. After spending several days inside the barrier reef and making a number of landings, the coast was quitted, and the course shaped for Timor. Oysters and clams were used to supply the place of pork, and the sick were stimulated by a few drops of wine after a night's exposure. The ten days spent in crossing from Australia to Timor reduced the boat's crew to the last stage of weakness, but the Dutch settlement at Coupang was reached without loss of life, and the sufferers were kindly relieved.

Bligh deserved credit for his success in controlling the distribution of provisions and for his skill as a navigator. Before crediting him with humane zeal for preserving the lives of his companions, we have to consider not only the stories of oppressive conduct and provocation for the mutiny, but also the fact that he was in haste to get home in order that a frigate might be sent to arrest the mutineers and bring them to punishment, and that his zeal was rewarded with partial success, though one of the midshipmen whom he had condemned as a mutineer lived to become post-captain in the British navy, while other rebels escaped to found the famous colony on Pitcairn Island, with the aid of a contingent from Tahiti. Bligh himself rose to high naval rank, but never attained popularity among those subject to his orders. Thus in 1808, when governor of Botany Bay, he was placed under arrest by officers who should have been his subordinates and actually held in confinement for two years before he was sent to England for the trial which resulted in his vindication. The trouble began over the governor's efforts to restrain the importation of liquor, and this seems to connect the two experiences of mutiny led by officers and due in part to oppressive interference

with the habits and comforts of those placed under his orders. Any tendency toward domestic or economic oppression must have been confirmed by the terrible trials of the voyage in the Bounty's boat.

Navigators bound for Europe generally shaped their course for the Cape of Good Hope from the Indian Archipelago without attempting to refresh in any port of the Asiatic continent or the islands of the Indian Ocean. European ships sometimes made unwilling acquaintance with other shores by shipwreck or marooning. Thus in 1601 a French squadron seeking trade in India was wrecked on one of the reefs of the Maldive group, and Pyrard de Laval was enabled to give a full account of the resources of these islands. Many fruits, roots, and grains were cultivated, though rice had to be imported from India. The smallest silver coin would buy a generous supply of provisions: 500 bananas, 400 cocoa-nuts, 300 pounds of yams, 100 large fish, or a dozen fowls, this system of equivalents being common in Oriental markets. Naturally the inhabitants of an archipelago of atolls and lagoons drew their chief aliment from the sea, and vast quantities of fish were dried or smoked for export after boiling them in salt water. The natives enjoyed a varied and delicate diet, and drinks were compounded by sweetening the milk of the cocoa-nut and making it hot with red pepper.

After sailing half way round the world as a pirate Dampier grew tired of the company and left the *Cygnet* at the Nicobar Islands. While ashore the marooned Englishmen lived on melory, a sort of bread made from beaten bread-fruit. A loaf of this with a bowl of toddy or palm-wine served very well for a morning repast, and the bread answered for sea-stores when they concluded to cross to Sumatra. As this voyage had to be accomplished in an out-rigger canoe only a slender stock could be carried; cocoa-nuts and bamboos held a supply of water, but neither men nor provisions could be kept dry during the gales encountered.

When seamen of English blood established regular traffic in the proceeds of piracy between the Indian Ocean and New York before and after 1700, Madagascar became a piratical naval station of some importance. The pirates went there to water and careen their ships; they found herds of cattle on the island, and from cattle-hunting they naturally turned to slave-trading, finding the

population numerous and unwarlike. Piratical kingdoms grew out of this traffic, but, though celebrated in legend, these predatory principalities were short-lived and shabby, for all their profusion in cattle and negroes and the treasure stolen from the ships of the Great Mogul.

The Cape of Good Hope was a Portuguese supply station before the Dutch made it a flourishing colony, producing European fruits and grains of excellent quality. The Dutch ship in which Dampier escaped from Bencoolen in 1691, had her crew prostrated by disease which was attributed to the badness of their water when they reached the Cape. The water had been taken from a tropical swamp, and the casks were stowed among the pepper in the hold so that the water was kept hot by the fermentation and was most obviously unfit for drinking. Living on shore and with abundance of fresh provisions soon restored most of them to health.

St. Helena became a station for supply and refreshment long before it had any permanent inhabitants. When Cavendish touched there in 1588 he found a chapel and a range of sheds and kitchens for the accommodation of sailors landed for refreshment. Lancaster found conditions unchanged six years later, except that an insane Portuguese was found in the chapel. Yet both got abundant supplies, and Cavendish describes valleys planted as orchards with lemons and dates, figs and pomegranates; "and in every void place is planted parsley, sorrel, basil, fennel, anise-seed, mustard-seed, radishes, and many very good herbs,"—many of them doubtless self-sown about the camps. The mountains swarmed with pheasants, partridges, and guinea-fowl. Thousands of goats, some of them "as big as an ass," roamed the hills along with "great store of swine which are very wild and fat." The Portuguese having planted the island for the benefit of their sailors, "suffer none to inhabit there that might eat up the produce of the island." The relief was necessary, no doubt, because the ships were "meanly victualled at their coming from the Indies, where there groweth but little corn," though they were "thoroughly furnished with corn when they set out from Portugal." Cavendish spent three weeks in taking advantage of the resources of St. Helena, with much benefit to his crew.

Ascension Island, with a smaller variety of vegetables, excelled St. Helena in its supply of turtle. These were readily taken dur-

ing half the year, and their eggs were also gathered for food. Springs at high level make watering most convenient, and the hills afford pasturage for large herds of goats—and for the sheep and cattle which have supplanted them,—and the shore abounds with fish. Here Dampier spent five weeks in 1701 with the crew of the *Roebuck*, a Queen's ship and the first vessel which he had commanded after she had foundered at sea. Ascension offered them "plenty of good turtle by their tents and water for the fetching."

This shipwreck was not the worst or the last of Dampier's adventures, but he wrote no narrative of his later circumnavigations, realizing, perhaps, that not even the literary art which taught Swift and De Foe how to narrate could redeem the discredit of his failures in command. Nor could the dietetic reminiscences of his piratical cruises been equalled by those of voyages in regularly supplied and commissioned vessels, even if advancing years and persistence in hard drinking had not impaired the keenness and courage which made him the greatest of dietetic chroniclers—though there are great names in the list of his rivals. Of the extent of his wanderings the preceding pages may give an idea, while the range of his vicissitudes in diet can be illustrated by numerous examples. Thus after leaving Juan Fernandez on a piratical cruise which lasted until the only ration was five green plantains a day for six men, a prize gave them a whole cargo of provisions, including flour, sugar, and thirty tons of the inevitable marmalade, to say nothing of such comforts as wine and brandy.

Dampier's early volumes are true epics of digestion. Youth and hunger often make men acquainted with strange meats, but this wanderer carried a cheerful and courageous curiosity into many a savage hut and grimy kitchen, and knew whether he liked what was set before him. His immediate reward was an intrepid eclectic habit unsurpassed in the annals of navigation and a discriminating taste in the comparison of viands. He was critical rather than greedy, and would have refused the label which Swift found current in polite company: "I am a fool; I like anything that is good."

The logwood-cutters of Campeche, among whom Dampier learned his trade of piracy, taught him also the craft of foraging in a savage or hostile country. They may also have been responsible for initiating him to the career of hard drinking. No ship

could open trade for their logwood until a bowl of punch had been set on the cabin table, and bargaining might be long postponed if the liquor proved attractive. The profit anticipated allowed shipmasters to be generous—for the sake of trade—and the Baymen were not above paying roundly for liquor. Any seaman that went ashore could have pork and peas, or beef and doughboys, and rum till the cask ran dry. Afloat the living was less pleasant. Dampier's ship sailed only two barrrels of unsalable beef on her return to Jamaica, her captain having neglected to provide other food, and the ship had to touch at the Alacranes for seals and fowls. The beef was consumed by cutting it into bits and mixing them with flour, the product being a most unsavory hodge-podge or spoon-victuals.

After this hungry voyage Dampier preferred to live with the logwood-cutters and to work as an axeman or a forager, though as one "whose genius led him rather to fish than to hunt," he soon gave up shooting cattle. The Spaniards had stocked the wilderness with these, and wild game was also plentiful; besides the peccary and the opossum," that we call pig, and I think it eats as well," the lagoons abounded with turtle, manati, and fish of various sorts, the tarpon being especially commended, though Dampier "never knew any taken with hook and line." There were land crabs, black and white, the blacks "fat and full of eggs and accounted the better meat, though both sorts are very good." The armadillo was very good eating; some thought the anaconda worth while; "I myself have tried it for curiosity, but cannot commend it." The alligator was too musky to be agreeable, though it was eaten in case of necessity. The crocodile, or what Dampier named thus, was savory meat. While cruising to capture supplies, Dampier grew familiar with the diet and drink of the Mexicans, with *tortillas* and a certain beverage made by stirring the ground corn in water and leaving it to ferment, when it had a sharp and pleasant flavor. It was improved by keeping and by the addition of honey. The ordinary drink for toilers and travellers was an unstrained mixture of the meal of parched corn with water.

When embarked as a buccaneer, Dampier had occasion to enlarge his dietary by the products of many latitudes. Fruit of all kinds he wisely enjoyed, not rejecting either prickly pears or durians, though these "send forth a most excellent scent," which

to prejudiced nostrils recalled roast onions—or something worse. Alligator pears or *avocados* might be "mixt with sugar and lime juice and beaten in a plate," or served with salt and a roasted plantain, and were excellent either way. The guava "bakes as well as a pear, and it may be coddled, and it makes good pies," to say nothing of the familiar jelly. For bananas and plantains, he has many recipes, some of which might reward the attention of those who have to be *aplateanado* by the staple product of the Philippines: green plantains roasted and dressed with salt, pepper-sauce, and lime-juice, are very savory; a roasted plantain and a ripe banana can be eaten sandwiched like bread and butter; mashed in a lump and boiled in a bag, sailors liked them for a pudding, "which they call a buff-jacket;" they can be made into tarts, dried like figs, or pounded into flour. Roasted ripe bananas squeezed up in a calabash of water make a pleasant drink, somewhat like the "lambs-wool" made with apples and ale in England. When Dampier first went to Mindanao they gave him a fermented drink of mashed bananas, and he "could relish no other drink they had there. It drinks brisk and cool and is very pleasant." These are not the theories of a man anxious to exploit a tropical estate or to defend a colonial policy but the notes of a sailor who had eaten his way around the world with a good appetite.

Dampier was not tempted to neglect the resources of the animal kingdom, but remained confidently omnivorous in every climate. Flamingos' tongues made a dish "fit for a prince's table;" iguanas were much esteemed for making broth for sick privateers; the fat of the tortoise of the Galapagos served to butter their dumplings and dough-boys. It was pleasant to serve green turtle and tortoise on alternate days, yet when beef came to hand after a long course of these luxuries the buccaneers were apt to fight over its distribution, as they did over most good things. On the other side of the Pacific the cocoa-nut fed hogs of Guam were much approved, "most excellent meat, the best that ever I did eat," Dampier declares. In Mindanao the buccaneers shot wild hogs by special request to protect the gardens, but found their social relations with the best Moro families temporarily interrupted because they ate the pork. After that they ate venison mostly, often killing sixteen or eighteen deer in a day. Dampier notes with admiration the dexterity of the Moros in taking ad-

vantage of the agglutinative properties of boiled rice in conveying it to the mouth.

After marooning Captain Swan among the Moros, the buccaneers cruised to the northward and visited the Bashi Islands at the northern extremity of the Philippine Archipelago. On these wind-swept islands the rank vegetation of the tropics does not flourish; their hill pastures are pleasant to the eye, and they now abound in cattle. Two hundred years ago goats and hogs were to be had, though fowls were few in number. Plantains, pumpkins and yams grew in the sheltered gardens, and sugar-cane was also planted. The natives were good-natured savages, fishers rather than hunters, and they rarely killed the goats—though they begged the offal of such as the English shot and cooked unsavory messes of fish in the uncleaned paunches. They caught locusts in hand-nets, a quart at a sweep, and parched them until they turned red and succulent. Perhaps Dampier thought them, like dried shrimps, "but a hungry sort of food."

The buccaneers named the group of islands from the native beverage, though a drink called *bashi* is in general use in many other islands. The northern variety owed its flavor to the addition of certain berries to the usual brew of cane-juice, and when drawn from the lees after three or four days it was not unlike English beer and was accounted a wholesome beverage by those who drank it copiously, and even by those who were often drunk with it. But Dampier has a good word for most liquors, even for those of the deadly *sam-shu* type of China, of which he avers that, "seamen grow fat by soaking this liquor."

His interest in liquors is too universal and his verdicts too lenient to leave much doubt as to his habits, particularly if the record of his unfortunate naval career be taken into account. The beverage brewed from pine-apples by the Mosquito Indians was not unknown to him, nor was palm toddy unacceptable. The spirit distilled from the fermented sap of the palm was esteemed as making "most delicate punch, but it must have a dash of brandy to hearten it." Lime-juice, now the standard preventive of scurvy, was then known chiefly as an ingredient of punch, the foundation of the conviviality of the eighteenth century. Punch had its influence at more than one crisis of Dampier's sea-faring life. He and his comrades reaped a rich harvest from the wrecks of the fleet which the Comte d'Estrées led to destruction on the

reefs of the Isle of Aves. Here they had casks of wine and brandy in their tents and lived "as merrily as if they had gone to Jamaica with thirty pounds in their pockets," and thought scorn of the man-of-wars' men who wanted food as well as drink. Yet when the crew of the *Cygnet* got arrack and honey in Mindanao, he records that they grew so disorderly and quarrelsome that he made up his mind to leave them at the first opportunity; "for I did ever abhor drunkenness."

Still he retained a simple taste for harmless beverages that somewhat mitigates his alcoholic offenses. He thought the milk at its best, its briskest and sweetest, when the cocoa-nut was almost ripe. He had a critical taste in cocoa and chocolate, and he gratefully remembers the Chinese tea-houses of Malacca, where a stiver bought a dish of tea and a little porringer of sugar-candy or other sweetmeat—a simple refreshment which Europe could not have offered at the price until long after 1700. When Dampier was a captain in the navy he went out of his way to get *verdona*, "a green, strong-bodied wine, harsher and sharper than Canary," because it would keep better in the tropics. He would not have echoed the opinion of Woodes Rogers, with whom he made his last voyage, who took more pains to increase his slender stock of liquors than he did to prevent them from sailing meanly clad, for "good liquor to sailors is preferable to clothing."

Dampier can hardly have been a manifest drunkard when he got a naval command on the strength of his literary success, or when he kissed Queen Anne's hand before sailing again as a privateer. Nor can he have exceeded the bounds of discreet conviviality when he dined with Mr. Pepys and Mr. Evelyn—no better company for a modest dinner in all England—and won the approval for better manners than might have been expected from a buccaneer. Dampier bought lemons and oranges for his crew, as well as a stock of strong waters, which he was careful to serve out whenever the watch got wet, though he found the men too apt to turn into their hammocks as soon as they had swallowed the dram without shifting into dry clothing, a practice which obviously caused a bad smell and probably promoted scurvy.

The hygienic practices recommended by Dampier at the close of the seventeenth century do not represent any advance beyond those which were put forth by Sir Richard Hawkins as the result

of his observations during the Elizabethan war with Spain. As with all captains who sailed the South Seas, the prevention of scurvy was Sir Richard's chief concern. He had no hesitation in blaming bad liquor, sour beer and the like, as the cause of frequent infection. He was accustomed to give his men a morning meal "at discharge of the watch," bread accompanied by a drink of beer or wine mingled with water; "the morning draught should be ever of the best and choicest of that in the ship." It must be remembered that he had no milder beverage to begin the day with; neither tea, coffee, nor chocolate being in use among Englishmen of that age. Woodes Rogers in 1710, after clearing ship to fight the Manila galleon off Cape St. Lucas, "ordered a large kettle of chocolate to be made for our ship's company, having no spirituous liquors to give them. Then we went to prayers; and before we had concluded, were disturbed by the enemy's firing at us." Dampier was present at these ceremonies, but we do not learn whether he performed similar rites before engaging the galleon which beat off his privateers in 1704.

Sir Richard Hawkins did not rely altogether upon the morning draught to keep his men in health, since he had some faith in drugs, "Dr. Stevens, his water," and "the oil of vitry." In fact, dilute sulphuric acid, two drops with water and sugar, may have been a rational prescription. But the sour oranges he also recommends doubtless furnish a better acid. Clean clothes and a clean ship, well scrubbed with vinegar and smoked with tar, are also good. But after all, "the air of the land" is the best remedy; "The oftener a man can have his people to land, not hindering his voyage, the better it is, and the profitablest course to refresh them." In diet his doctrine was equally sound; he warned seamen "to feed upon as few salt meats as may be, and especially to shun salt fish." Nor would he have food dressed nor clothes washed in salt water.

No Elizabethan seaman could afford to neglect these topics. Hawkins estimates the loss of men from scurvy in the navy of his generation as no less than 10,000, doubtless kept within the limits of a fair estimate. Drake, who was notoriously a careless purveyor, lost a fourth part of his force of 2300 men in the West Indian voyage of 1585, while the cruise of 1589, "a miserable action" in all respects, cost him nearly half of the soldiers and sailors embarked, a sacrifice of perhaps not less than 6000 lives.

Many of these died from the results of excessive drinking in the wine-cellars of Coruña. An attempt to repeat Elizabethan exploits at Cadiz under the incompetent management of favorites at the court of the Stuarts led to even more calamitous revels, followed by great mortality. Sir Edward Cecil was a veteran soldier, but he could find no better excuse for his failure than this: "if any man can tell me where an army hath been kept in any order where wine was, I will profess my ignorance."

Even more deadly to the seaman of that day than the strong wines of Spain was the feminine thrift of the sovereign, who regarded every cruise as a commercial speculation and sought to risk as little as possible by restricting the supply of provisions. For mere "actions of honor" or attempts to destroy the military power and prestige of the enemy she was neither generous nor appreciative. Even with the *Armada* in the Channel, it was hard for her admirals to find money to buy beef and beer for daily rations; while the purchase of "extraordinary kinds of victuals," such as wine, cider, sugar, oil and fresh fish, for the benefit of the sick was held unlawful, and the cost ruthlessly exacted from the grumbling Lord Admiral. Nor were the sailors who manned the privateering fleet any better provided than those who served the Queen. In fact the condemned or surplus stores of the royal navy were worked off on the merchantmen and privateers by restraining the butchers of London from selling meat to ships while any useless stock remained unsold in the naval depots.

The true methods of reforming naval diet date from the latter part of the eighteenth century, and the chief agent and advocate of a rational and humane system was James Cook, who began his sea-faring life in a Newcastle collier and closed it on the shore of Hawaii in 1779 as a captain in the royal navy. His intense feeling concerning questions of diet appears in the fervent phrases of his narrative; thus the hardships of an Antarctic cruise were "compensated by the singular felicity we enjoyed of extracting an inexhaustible supply of fresh water from an ocean covered with ice." He believed that the art of man or the bounty of nature had provided in every part of the world "some sort of refreshment or other, either in the animal or vegetable way," and he strove to compel his people to reap the benefit of every opportunity for refreshing themselves accordingly. Incidentally he had to employ his authority—his example was never lacking—to pro-

mote the consumption of so many plants not hitherto accounted as edible. Though Cook died in the faith that his zeal had made many unwilling converts, we learn from the journals of some of his officers that not every stomach could accept his decoctions, some of which are frankly labelled nauseous. Spruce-beer was never a favorite beverage, and it would appear that in search for cordials and simples some actual hazards may have been encountered.

Not all of Captain Cook's suggestions have been rendered obsolete by scientific progress and commercial enterprise. He regards both sugar and sauerkraut as wholesome food with an anti-scorbutic tendency. Portable broth to be boiled with oatmeal for breakfast and with vegetables for dinner, was one of his favorite articles of concentrated food. The rankness and bitterness of wild greens would be subdued by this treatment, and he appears to have been one of those who prefer to make farinaceous foods savory rather than sweet. The American notion of blending lard and sugar with flour to make pies and cakes, contrary to the practice of the thrifty southern races who flourish on pilaffs, risottos and macaronis, is plainly an unwholesome as well as an expensive heresy, especially where it is accompanied by meats served in masses instead of being made to furnish savory soups and extracts for making flour and grains more nutritious and attractive. Lime-juice Cook believed in as an antidote to scurvy, but he left it in the hands of the surgeon while he undertook to find food which should render the surgeon's task a light one. Instead of "the rob of lemon or orange," as Cook called it, Nordenskiold used the juice of a northern berry, the cloud-berry, he names it, judiciously blended with a daily dram, and he carried a stock of ripe potatoes sealed in barrels of molasses. Thanks to these precautions, he was able to accomplish the circumnavigation of Asia without suffering the disgrace of having his crew harassed by scurvy.

There have been reformers in the field since Cook's day, and there will be room for successive generations of improvers of naval diet as long as man follows the sea. Just now the problem seems to be to secure an honest correspondence between the contents of tins and the labels they bear. The time may come when an effort will be required to liberate naval seamen from the vanity and artifice of an elaborate imitation of the bills of fare of a

fourth-rate American hotel as well as from a slavish dependence on the staple products of the packers. In either case Cook's lessons are not exhausted until an equal attention is bestowed upon both sea-stores and refreshments, or until the natural productions of every region accessible to shipping are used under natural conditions in preference to preserved foods, whether these are stale and unwholesome or simply monotonous and expensive. But most reforms in the diet of sea-farers will be developments of the ideas of the man who invented wholesome methods in the eighteenth century and reversed the ponderous verdict of Doctor Johnson, who declared that a man-of-war was less fit for habitation than a penitentiary, because the latter offered "better air, better food, and better company." Captain Cook was aware that if he could remove two-thirds of that reproach time would redeem the rest.

CAPTAIN (COMMODORE) THOMAS TINGEY, U. S. NAVY.

COMMANDANT OF THE WASHINGTON NAVY YARD, 1800-1829.

(From an original engraving by C. B. J. F. de St. Memin, in the possession of Mrs. Aulick Palmer, Washington, D. C.)

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

CAPTAIN THOMAS TINGEY, U. S. NAVY.[1]

By Mr. F. W. Hackett.

The American people have awakened to the value of historic associations. They are minded that hereafter no site of a noteworthy public event shall go unmarked. In this spirit we are here to commemorate the beginnings of the Washington navy yard.

Congress, by act of February 2, 1799, authorized the building of six ships, of seventy-four guns each. The Secretary of the Navy named Washington as a place where one of the ships should be built. He bought for $4000 a tract of 40 acres here on the eastern branch. Benjamin Stoddert, of Georgetown, was a sagacious man of business. He looked the country over to discover a person suited to the task of laying out and getting into working order the new yard. Plans drawn by the ingenious Latrobe he had in hand, but what he wanted was a man of administrative ability, of experience and sound judgment as to building and fitting out ships of war, and maintaining a plant for speedy repairs. Such men were rare in those days.

There was living, however, at Kingston, N. J., "an officer," to quote the Secretary's words, "of great merit in our service. * * * A man of understanding, who, having seen the navy yards of England" would "be able to direct the laying out of that in Washington to the greatest advantage." In obedience to a summons this officer came here in midwinter to a place that was little better than a wilderness. Walking around the tract—at some points drifted snow had covered up the stake and stone—the new-comer examined the lay of the land, and the water facilities,

[1] An address delivered at the unveiling of the Tingey Tablet at the Washington Navy Yard, November 20, 1906.

and pronounced the site "eligibly chosen." With the advance of the season he erected a high board fence, and had men at work building a wharf. From this date down to February, 1829, the man diligently applied himself to the growth and development of this yard; and when death overtook him here, at the age of almost eighty, all Washington mourned the loss of a friend. To-day we do honor to the memory of Capt. Thomas Tingey of the United States Navy.

The son of a clergyman, he was born at London, England, on the 11th of September, 1750. When not quite twenty-one he was put in command of a blockade house and a guard of twenty-two men at Chateaux bay, on the coast of Labrador. This was Fort Pitt, built in 1763 to protect the fisheries. Tingey's orders were from Commodore Byron, then governor of Newfoundland—grandfather of the poet—a somewhat eccentric commander, known to the service as "Foul Weather Jack." They bear date 31 July, 1771, from on board the *Panther*, at St. John's; and they direct Mr. Tingey to proceed in the sloop *Nautilus* to his lonely destination.

Tradition says that young Tingey resigned from the British navy because of a difficulty with another officer. However this may be, he seems to have found his way to these colonies. The statement also rests on tradition that he served in the continental navy, and at the close of the Revolutionary war made his home in New Jersey, where he entered into trade with the East Indies.

Sometime, while our infant navy was getting itself born, Tingey appears to have returned to his profession; and by the last years of the century he had gained repute as an officer of superior talent. Upon the reorganization of the navy, in 1798, the President named him as one of the additional captains, and gave to his commission the earliest date of the five then appointed. Capt. Tingey was assigned to the command of the *Ganges*, twenty-four guns, then fitting out for sea at Marcus Hook. He ranked third in the squadron for the West Indies, his seniors being Barry and Truxtun.

Two small vessels were added to his command, and he was ordered to guard the Windward passage, between Hispaniola and Cuba. The duty of protecting our merchant vessels against the attack of French privateers he performed with spirit and with due circumspection.

One day the *Ganges* was entering the port of St. Thomas. Her commander had learned that it was the intention of the Danish authorities, when he should have saluted their flag, to return the salute with a smaller number of guns. He sent an officer on shore to inform the commandant of the port that the Danish flag would be saluted only upon condition of return of gun for gun. Needless to say, the condition was complied with.

During the same year (1799), Tingey fell in with a British frigate, whose captain dispatched an officer to the Ganges to make inquiries with regard to the presence on board of British seamen. Capt. Tingey was informed that his simple assurance would be sufficient to prevent an officer being sent to examine the protections of his crew. "I did not hesitate to say," so he reports to the department, "that I considered all my crew Americans, born or adopted; but I told the officer further that I did not believe there was one single protection in the ship, the only one we carried in our public ships being our flag." He adds that he had declared to his officers a purpose to fall at his post rather than to submit to an investigation; and that he had pledged himself to his crew that not a man of them should be taken from the ship by any force whatever while he was able to stand at quarters.

In replying, March 7, 1799, the Secretary says: "The President highly approves of the conduct you pursued with regard to the British frigate you fell in with."

This behavior on the part of Capt. Tingey furnishes one of the earliest instances of that determined resolution evinced by the little American navy, which at last compelled England to abandon the position she had assumed of exercising the right to take away from whatever deck she should find him upon a man whom she deemed to be a British subject.

What with convoying merchant vessels, visiting different harbors and chasing privateers, Tingey was kept busy enough. His most important capture was that of the *Vainqueur,* eight guns and eighty-five men, a swift vessel, overhauled only after a chase of ninety miles. Upon the signing of the treaty of peace with France our navy was reduced, and many officers, of whom Tingey was one, were discharged. He returned to his home in New Jersey, and again applied himself to mercantile pursuits.

But the public demand for a navy, which Congress in part had answered by providing for these six seventy-fours, would not

suffer such a man as Tingey to remain long out of the service. As we have seen, he was sent for to come to Washington and call into existence a navy yard.

He was first made superintendent, and, then, in 1804, by virtue of a special act of Congress, he was reappointed a captain in the navy and commandant of this yard. Energy and discretion marked his administration of affairs. He was zealous and untiring. The valuable historic sketch of the yard, by Chaplain Hibben, speaks of its first commandant in terms of unqualified praise. It alludes particularly to the mass of letters on file at the department, all written in his own hand, as proving with what painstaking fidelity he looked after detail of these many exacting duties.

In 1808 Tingey submitted to the Secretary of the Navy a set of rules for the government of the yard. So well adapted were they to their purpose that the department applied them to every yard on the coast. Preble says that they appear to be the basis out of which have grown all the subsequent regulations for the government of our navy yards.

There is a chapter in our early annals of which, it would seem, we have small reason to be proud. In 1814, when the British forces entered Washington, the responsibility lay upon Capt. Tingey of protecting this navy yard, with its vessels and stores.

Much working at cross purposes, and consequent confusion, marked what by a stretch of courtesy may be entitled the defense of Washington on that unfortunate occasion. Upon the night of the 24th of August three great fires lighted up the sky. There were burning at the same time the Capitol, the White House and the navy yard. Secretary Jones had given to Captain Tingey a positive order (said to have been agreed to by the unanimous vote of the entire cabinet) which compelled that officer most reluctantly to apply the torch. Fortunately, the commandant's house was spared from the flames. Tingey's report of his performance of this duty reveals the character of the man.

Captain Tingey in his long residence here showed himself to be a good citizen as well as a valuable officer. He took a lively interest in what was going on in Washington. He knew and liked the townspeople. They liked and admired the "Commodore," as the commandant of a navy yard was in that day popularly styled. His name heads the list of the vestry of Christ

Church in 1806. He was an incorporator of the cemetery of that church—now the Congressional cemetery. His remains lie at the entrance, close to the office of the superintendent, so that the stone to his memory is the first object that greets the visitor.

Captain Tingey was a man of fine proportions and of handsome features. He had a dignified and courtly bearing. He was fond of society, where his knowledge of the world and really kind heart made him a general favorite. He maintained health and strength to an unusual age, and was "busy in these scenes until the last plaudit."

Is it too much to believe that this excellent officer had transmitted to his descendants somewhat of his own gallant spirit? His grandson, Thomas Tingey Craven, born at this yard, fought the *Brooklyn* at the passage of the forts below New Orleans; while another grandson (brother to Thomas), Tunis Augustus MacDonough Craven, went down with his ironclad *Tecumseh*, in Mobile bay, quietly stepping to one side at the foot of the ladder, that the pilot might rush up and escape with his life.

May this yard long continue to prosper and grow more and more useful to the country. Happy, indeed, is it that its early fortunes were presided over by so true a man as Thomas Tingey.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE SIZE OF BATTLESHIPS AS A FUNCTION OF THEIR SPEED.

By M. J. A. NORMAND.

Translated from the "Bulletin de L'Association Technique Maritime,"

By PHILIP R. ALGER.

The Russo-Japanese War, and particularly the naval battle of Tsushima, have revived the discussion of the value of speed for fighting ships. One can hardly say, however, that much light has been shed on the question, since diametrically opposite conclusions have been drawn from the facts.

On the one hand, a reduction of speed allows giving a ship of fixed dimensions greater offensive and defensive power, or, if the latter remain the same, diminishing her size and in consequence, for the same initial expense, increasing the number of units and putting in the line of battle more gun-power.

Considerations as to the accessibility of harbors and the utilization of their workshops; of possible employment of old and less speedy units in squadrons without compromising the latter's homogeneousness; of seas or canals in which the squadrons must operate; of the proportions of the engines and of the conditions of installation and service of the magazines, the more favorable as the speed is less, militate in equal degree in favor of low speed.

On the other hand, great speed may be demanded for strategical or tactical reasons.

The question cannot be rigorously treated unless we know the law, in accordance with which the absolute size of large fighting ships varies with their speed, when their offensive and defensive powers, as well as their radius of action, remain unchanged.

The object of the present note is to find this law.

Let there be a battleship differing little from the English type *Commonwealth*, the last class of which the results of the trials are known.

Total length of hull (L)	138.00 m.
Maximum width of hull	23.80 m.
Draft	8.15 m.
Height of upper deck above water-line, at middle of length	6.20 m.
Area of immersed part of midshipsection (B^2)	180 sq. m.
Displacement with normal coal supply of 1,000 tons (D)	16,600 tons.
Maximum horsepower	18,000
Corresponding speed (V)	19 kts.
Weight of propelling machinery complete, with water	1,800 tons.

Artillery.—Four 30.5 cm., four 24.3 cm., ten 15.2 cm., fourteen 7.5 cm., fourteen 4.7 cm. This battery, which is that of the *Commonwealth*, appears to comprise too many different calibers, but the weight which it represents is about that of the most modern armament of a ship of this kind.

Protection.—This consists of an exterior belt rising in the central part to the upper deck, and of 23 cm. thickness at the water-line, diminishing to 16 cm. at the upper deck. The protection of the ends is weak, especially at the stern.

Let us first determine what increase of available displacement would be given by a reduction in speed of one knot.

This increase is made up of three principal items:

1. THE INCREASE OF DISPLACEMENT RESULTING FROM DIMINUTION OF FINENESS OF LINES.

Considering the formula for maximum normal speed[1]

$$V = 1.4 \frac{1.026\, B^2 L - D}{1.026\, B^2} B^{\frac{1}{2}}.$$

We see that this speed is proportional to the fineness of lines (sharpness), a fractional term, and to the square root of the linear dimensions ($B^{\frac{1}{2}}$), according to the law of Reech and Froude.

It has been shown, in the table annexed to the note cited,[1] that the speeds thus calculated approach closely the maximum speeds realized, or, at least, that they sensibly follow the same law of variation; the formula, therefore, appears to conform both to theory and to practice.

The coefficient 1.4 is a mean value.

[1] Approximate rules for the calculation of the propulsive surface (Bulletin de L'Association Technique Maritime, 1899, p. 7).

Let us calculate, for a large ship which has realized a maximum speed V, the coefficient K such that

$$V = K \frac{1.026\ B^2L - D}{1.026\ B^3} B^{\frac{1}{2}}. \qquad (1)$$

We have a right to assume that, if we reduce the speed of this typeship by one knot, B^2 and L remaining the same (such are the conditions of our problem), and make the displacement D vary so that K retains the same value, the "coefficient of propulsion" will not vary; in the two cases the water will be displaced in equal times.

Formula (1), differentiated with reference to V and D, the only variables, gives

$$\frac{dD}{dV} = -\frac{1}{K} \frac{1.026\ B^3}{B^{\frac{1}{2}}},$$

or, replacing $B^{\frac{1}{2}}$ by its value from (1), and noting that, the above coefficient being constant, the differentials may be replaced by finite differences,

$$\frac{\Delta D}{\Delta V} = -\frac{1.026\ B^2L - D}{V}. \qquad (2)$$

From the elements of the battleship type given above, we find for K the value 1.446, which corresponds to great fineness of lines for such a ship, and formula (2) then gives for $\Delta V = -1$,

$$\Delta D = 468 \text{ tons}.$$

The surface, and consequently, the weight of the hull, being slightly increased, we will take as the available increase only 450 tons, or, 2.7 per cent of the original displacement.

For $\Delta V = +1$, that is to say, for an increase instead of a decrease, of one knot in the speed, the change of displacement is negative and equal to -450 tons. On account of the necessary increase of fineness, there results a deficiency of displacement of 450 tons.

2. THE DIMINUTION OF WEIGHT DUE TO REDUCED POWER.

The fineness of lines being modified to correspond to the reduced speed, and the two other principal elements of the resistance, area of midship section and surface of hull (the latter is not materially increased) remaining the same, it is very probable that the "coefficient of propulsion" does not vary, and that the powers

are proportional to the cubes of the speeds, or, for a reduction of one knot, as

$$\left(\frac{18}{19}\right)^3 = 0.850.$$

If the weight of the propelling apparatus varies as the power, the reduction would be

$$(1 - 0.850)\ 1800 = 270 \text{ tons.}$$

This is very nearly the case for the boilers and condensers; the stacks are, it is true, heavier per horsepower, but the relative weight of the tubing is less, and the fuel handling requires a smaller personnel, all proportions considered.

For the machinery, on the contrary, not only does the length of the lines of shafting not change, but, as M. Durand-Viel has shown in a remarkable memoir which has just appeared in the *Revue Maritime*, for the same ratio of pitch to diameter and the same value of the coefficient of propulsive surface j, the weight of the machinery (about half that of the whole propelling apparatus) varies as $V^{5/2}$ instead of V^3.

The relative weight of the less powerful propelling apparatus complete is then about

$$\tfrac{1}{2}\left(\left(\frac{18}{19}\right)^3 + \left(\frac{18}{19}\right)^{\frac{5}{2}}\right) = \tfrac{1}{2}\ (0.850 + 0.875) = 0.8615$$

and the reduction of weight is

$$(1 - 0.8615)\ 1800 = 250 \text{ tons.}$$

This reduction of weight changes to an increase if the speed of the battleship type, instead of being diminished from 19 to 18 knots, is raised from 19 to 20 knots.

It is interesting to note that the less powerful machinery works under better practical conditions, and will more easily maintain its full power.

M. Durand-Viel shows, as a matter of fact, in the memoir already referred to, that, for the same ratio of pitch to diameter and the same value of the coefficient j, the ratio of the linear dimensions of the engines to those of the hull is independent of the displacement, and varies as $V^{5/6}$, that is almost as the speed. Either the stroke is kept the same, which is possible since the dimensions of the hull remain unchanged and the cylinder diameters are diminished, or the piston speeds are notably reduced.

3. THE REDUCTION IN WEIGHT OF THE UPPER WORKS.

It is difficult to accurately estimate this saving, although it undoubtedly occurs; a ship hindered by a seaway behaves better, and is less wet, when her speed is reduced.

The course which makes speed less than the maximum necessary, either to keep the sea without exhaustion or to use the guns, is principally that on which the ship receives the waves from forward or on the bow, the time occupied in rising from the hollow to the crest of the wave being then inversely proportional to the ship's speed increased by the speed of the wave. The most unfavorable sea is that producing short waves, consequently of low speed, such as those of the Mediterranean.

Let 15 knots be the speed of the waves; it may be assumed that the conditions of navigability will be the same for the battleship of eighteen knots and the one of nineteen knots, when, the underwater bodies being the same, the heights of the upper works are in the ratio.

$$\frac{18^{kn} + 15^{kn}}{19^{kn} + 15^{kn}} = 0.9706.$$

The height of the upper decks above the water-line at middle length, which is 6.20 m. in the typeship, can therefore be lowered $(1 - 0.9706)\ 6.2 = 0.183$ m.

The thickness of the outer armor plating being 16 cm. at its upper part corresponds approximately, taken together with the side supporting it, to 22 cm. of steel, and its total length on the two sides and the transverse bulkheads is 184 meters. This length may without exaggeration be taken as of 22 cm. thickness, taking account of the considerable excess thickness of the turret supports and of the various armored passages whose heights are simultaneously diminished. The saving of weight then would amount to

$$220 \times 0.183 \times 0.22 \times 7.8 \text{ tons} = 69.2 \text{ tons}.$$

This reduction of 0.183 meters in the height of the upper works does not seem excessive when it is remembered that there are battleships whose freeboards are much less than that of our typeship, the *Hood* for example—a rather poor seaboat, it is true—of 15,600 tons and 17½ knots, whose freeboard forward is less than 4 meters, an amount at least 2.2 meters less than that of the typeship.

The reduction of 0.183 meters per knot, supposed constant, corresponds, therefore, to a reduction in speed of the typeship of from 10 to 12 knots in order that she may find herself in the same condition as the *Hood* in the matter of the height of upper works.

The height of the guns ought, it is true, to remain such that their fire shall not be interfered with by the waves under any condition of the sea which would permit fighting; that of our type battleship, 8.5 meters, would appear to allow of reduction. Moreover, the height of turret guns can be maintained even while that of the upper works of the ship is reduced; the saving of weight would still be considerable, and the stresses on the deck due to firing the guns would be diminished.

We will take no account of the saving of weight which the space made available by the reduction of the propelling machinery would enable us to make in the superstructures, which we will assume to be reduced to a minimum, as they should be. So, too, we will merely note the reduction of the personnel of the motive power.

It is clear that an increase instead of a reduction of speed of one knot would merely change the sign of the corresponding change of weight.

To sum up, the reduction of the speed of the type battleship from 19 to 18 knots would furnish an increase of displacement of 450 tons and a saving of weight of $250 + 69 = 319$ tons, or a total availability of 769 tons (4.63 per cent of the initial displacement), which can be used to increase either the protection, the artillery, or the radius of action, the ship retaining meanwhile the same draft, length, and beam, and remaining equally seaworthy. The displacement, which was 16,600 tons, would become 17,050 tons.

The availability of 769 tons may be otherwise employed: it may be utilized to reduce the size of a ship.

It is known, as a matter of fact, that any saving of weight $\Delta\pi$ realized on a ship, permits reducing her displacement, by an actual decrease of size, by an amount $K'\Delta\pi$ notably greater than $\Delta\pi$, the speed, radius of action, seaworthiness, protection and offensive power remaining the same. If $\Delta\pi$ represents an addition instead of a saving of weight, it is necessary, on the contrary, to increase the displacement, by making the dimensions bigger, by the same quantity $K'\Delta\pi$.

The coefficient K' varies according to the type of ship. It is approximately equal to

$$\frac{\Delta D}{\Delta \pi} = \frac{3}{1 - a + \frac{2P}{D}}$$

in which a represents the fraction of the total displacement taken up by the weight of the hull and equipment, without armor, artillery, ammunition, or stores, and P is the fixed weight of artillery, turrets, ammunition, and stores, but not the hull armor, which latter varies with the hull surface.

Whether we use this formula, which I gave in 1885, or the slightly modified ones which have been proposed since then, it will be found that, for battleships of the type considered, the value of K' differs little from 2.5.

If then the available 769 tons be applied to reduce the actual size of the ship, the displacement will be diminished by

$$769 \times 2.5 = 1922 \text{ tons}$$

and will become

$$16{,}600 + 450 - 1922 = 15{,}128 \text{ tons.}$$

For a reduction in speed of two knots instead of one, the displacement, at 17 knots instead of 19 knots, would be about

$$16{,}600 + 450 \times 2 - 1922 \times 2 = 13{,}656 \text{ tons.}$$

This figure is too low and ought to be taken rather at 13,800 tons, for the variations corresponding to two knots' difference of speed are too great to be calculated exactly by the differential coefficient method; moreover, it is necessary to take account of the fact that the fineness of line of the hull ought to be slightly increased for an equal speed with less actual size.

Thus, we see that, if the preceding calculations are correct, in taking as unity the displacement of a battleship of 16,600 tons, 18,000 horsepower and 19 knots, the displacements of similar ships having equal offensive and defensive powers, the same radius of action, and the same seaworthiness, and only differing in speed, are approximately at

17 kts.	0.83
18 "	0.91
19 "	1.00
20 "	1.10
21 "	1.20

At 17 knots the displacement would be about 13,800 tons, and at 21 knots about 20,000 tons.

Since the draft of large battleships cannot without much inconvenience be increased, and since the vertical space available for the machinery is sensibly constant, it will be seen that the proportions of the latter, supposed to be of the reciprocating type, become more and more defective as speed is increased. From this point of view, steam turbines have a serious advantage.

The comparison of the battleships of *Kansas* type and those of *Idaho* type now being built for the U. S. Navy seems to confirm the above calculated results.

The very powerful artillery and the protection are almost identical in the two cases, but the displacements are 16,000 and 13,000 tons, and the horsepowers 16,500 and 10,000, respectively.

These ships not being yet delivered, their speeds are not exactly known, but admitting an equal propulsive efficiency for the two types, we find that for 18.5 knots, the speed of the *Kansas*, the *Idaho* should attain 16.5.

To this difference of two knots corresponds a ratio of displacements equal to 0.814.

This result agrees with the practical rule given above.

The maritime world is greatly preoccupied with the *Dreadnought*. Whatever may be the differences, still very imperfectly known, between this battleship, celebrated before being born, and the most powerful ships of recent construction, in artillery, protection, and motive power, there ought not to result therefrom any change in the formula given above. The constants will merely have to be more or less modified.

I am first to recognize that in these calculations a large part is hypothetical.

The problem of which I have attempted to give an approximate solution is of great interest, and merits a more complete study.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

COMMENTS ON "THE SIZE OF BATTLESHIPS AS A FUNCTION OF THEIR SPEED."

By NAVAL CONSTRUCTOR D. W. TAYLOR, U. S. Navy.

This very interesting and suggestive article by the late M. Normand bears upon one of the questions in naval architecture which is just now of vital interest. M. Normand has taken the published data for an actual ship and developed an approximate formula for the purpose of determining the displacement and power of ships of the same midship section and length but greater and less displacements with less and greater speeds. This falls into a class of problems which can be dealt with very directly by model basin experiments, and at the request of the Secretary of the Naval Institute I will indicate the solution of this particular problem, which we obtain from our accumulated data.

We are not able to take up the investigation with knowledge of the actual lines of the *Commonwealth*, but it happens that we have run at the Model Basin a series of models of ratio of beam to draft very close to that of the *Commonwealth*, and varying in fullness and displacement. From the results of this series we can determine the effective horsepower for any model within limits upon the parent lines of any size and fullness. To connect this result with the *Commonwealth* data it is simply necessary to assume an efficiency of propulsion (which happens to be a little over 50 per cent) which will give our ship derived from the series lines and having the same midship section area and fineness as the *Commonwealth* a speed of 19 knots upon 18,000 horsepower. Applying this efficiency of propulsion to the curves of effective horsepower, we are enabled to readily produce the curves of estimated indicated horsepower of Fig. 1 for vessels 452.8 feet long, with 1938 square feet area of midship section, and of displacement

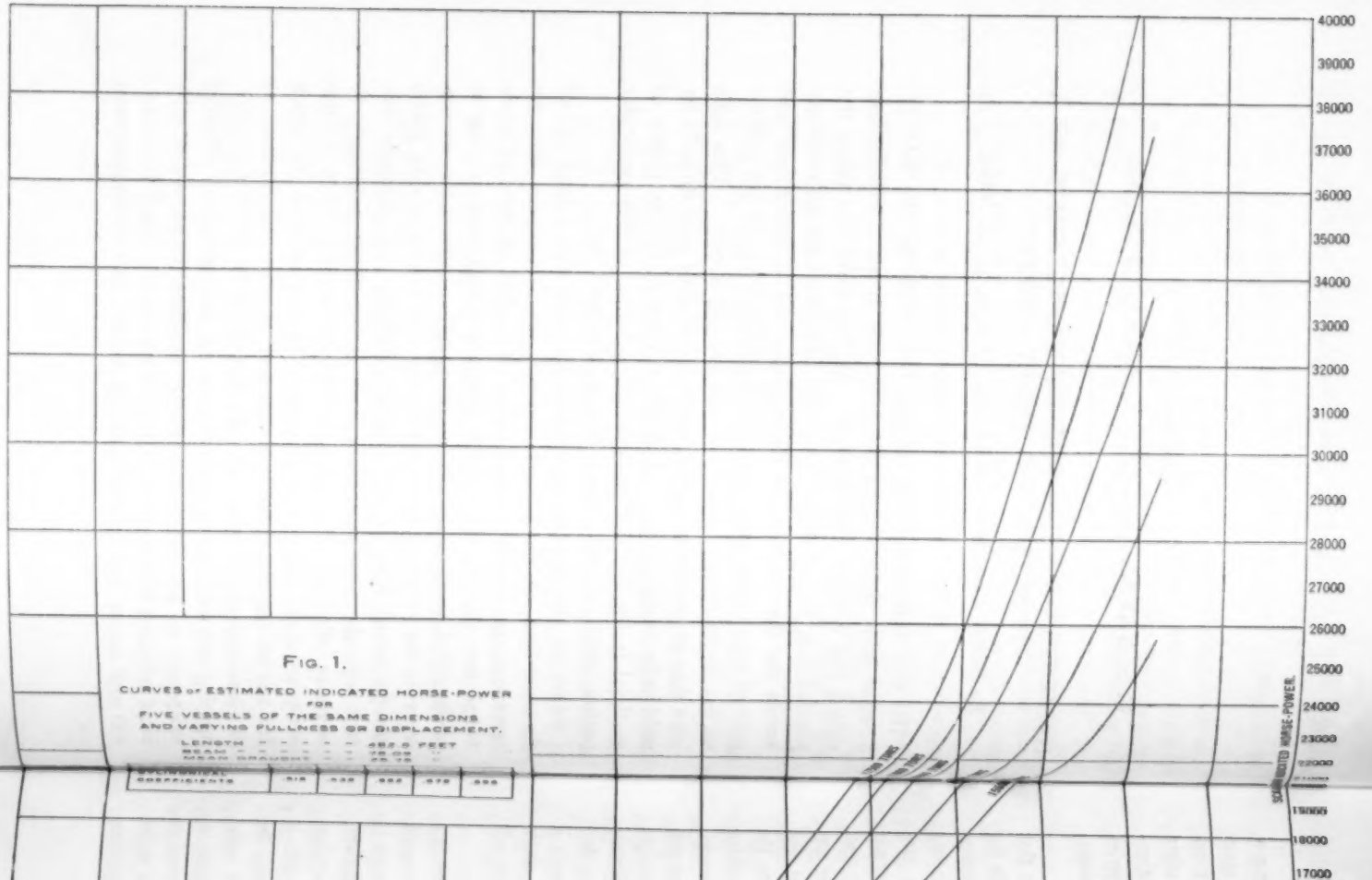
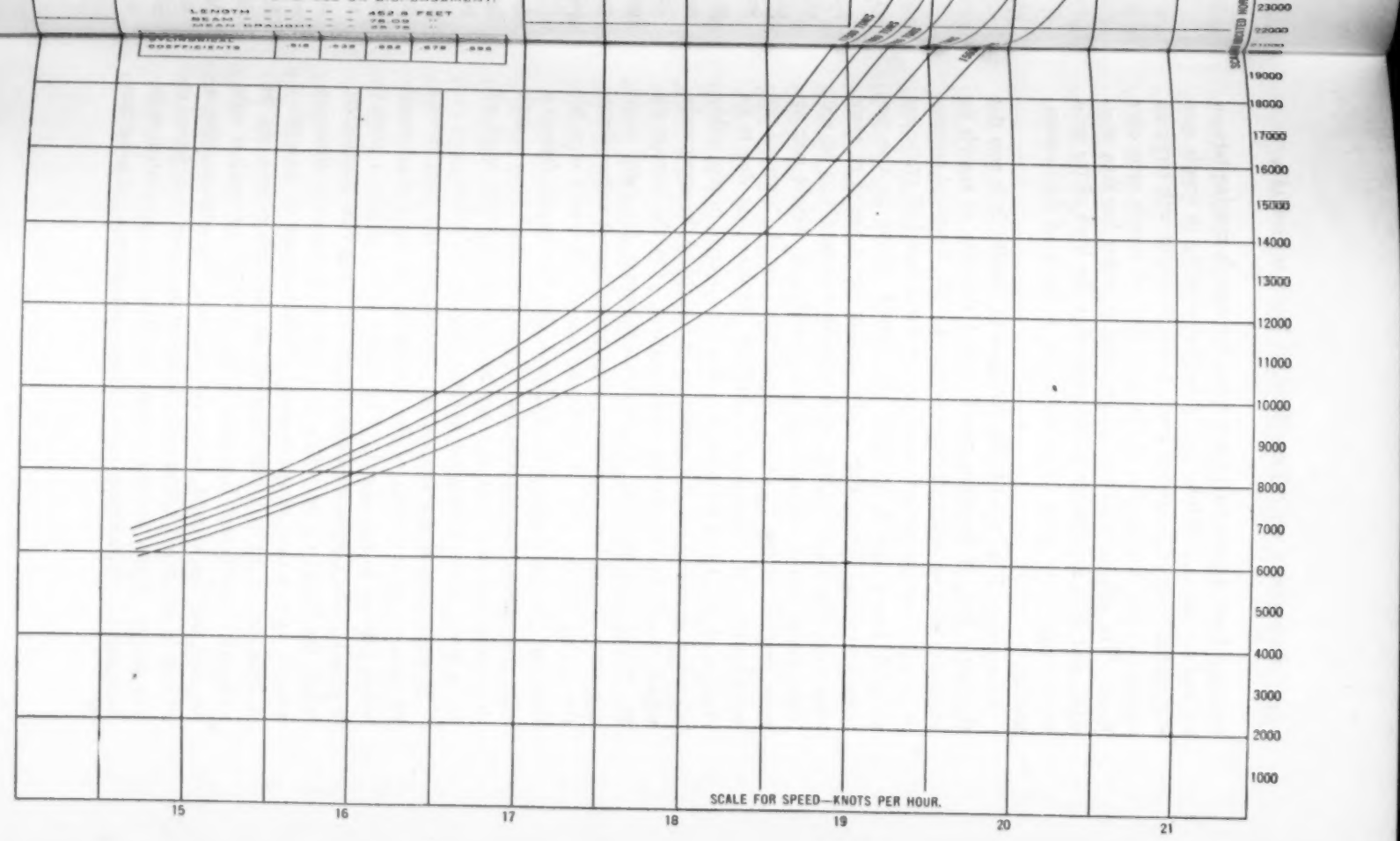


FIG. 1.

CURVES OF ESTIMATED INDICATED HORSE-POWER
FOR
FIVE VESSELS OF THE SAME DIMENSIONS
AND VARYING FULLNESS OR DISPLACEMENT.

LENGTH - - - - - 482.5 FEET
BEAM - - - - - 75.00 "
MEAN DRAUGHT - - - 25.75 "

SYSTEMATIC COEFFICIENTS	.515	.555	.594	.570	.555


LENGTH
BEAM
MEAN DRAUGHT
COEFFICIENTS
SCALE FOR SPEED—KNOTS PER HOUR.
15
16
17
18
19
20
21
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
17000
18000
19000
22000
23000

ranging from 15,500 to 17,500 tons, for speeds ranging between 15 and 20 knots. While Fig. 1 applies directly to vessels upon the parent lines of the series used, it will represent with very good approximation the nature of the variation of vessels upon other lines. The efficiency of propulsion used is rather low than otherwise, and it is reasonable to suppose that the lines of the series used would drive very much the same as those of the *Commonwealth*.

Comparing Fig. 1 with M. Normand's results, it is seen that the latter has, if anything, understated the case as regards the saving of weight and reduction of speed. M. Normand estimates at 15 per cent the reduction of power for a vessel of 17,050 tons and 18 knots speed, making the actual power as thus estimated 15,300. From Fig. 1 the power for a vessel of 17,000 tons would be about 13,600, or a reduction of nearly 25 per cent. This would make the reduction in machinery weight over 400 tons, instead of the 250 tons as estimated by M. Normand, and would make M. Normand's available displacement due to the change of speed and fullness over 800 tons instead of 769, without allowing anything for the reduction in weight of the upper works, which would be somewhat problematical. On the increase side M. Normand's formula would underestimate the extra weight necessary to put into machinery even more than it underestimates the saving on the side of decreased speed. It would seem then that, for the particular case in hand, M. Normand's formula is very conservative as regards the influence of speed upon available displacements, and that the saving through reduced speed will be in some cases somewhat greater than he indicates.

In this connection attention may be called to the great influence of fineness upon vessels of the dimensions of the *Commonwealth* when pushed to top speed. The upper curve of Fig. 1 refers to a vessel of the *Commonwealth* length of 17,500 tons displacement, while the lower curve refers to a vessel of the same dimensions and of 15,500 tons displacement. This increase of 2000 tons is a little under 13 per cent figured on the 15,500 tons, and the cylindrical coefficient increases from .618 for the smallest vessel to .698 for the largest one. At 16 knots the corresponding increase in indicated horsepower is about 14.5 per cent, figured on the power of the smallest vessel, or almost in proportion to the increase of displacement. At 17 knots the increase of power from

the smallest to the largest vessel is 17.5 per cent. This percentage shows again a moderate rise at 18 knots to 21¾ per cent. At 19 knots there has been a rapid increase to 37 per cent, and at 20 knots this increase of 13 per cent in displacement upon the same dimensions involves an increase of 57 per cent in power. Nineteen knots is about the extreme limit of economical speed for a vessel 450 feet long, and if such a vessel is to be pushed to a higher speed it is necessary to fine her radically.

The connection between speed and length is very important. Reduction of speed allows length, which is the most objectionable dimension of a man-of-war, to be reduced, as a rule, more than in proportion to the reduction of displacement. Thus, in the case of the *Kansas* and *Idaho*, referred to by M. Normand, the displacements are in the ratio of 13/16, or .8125. If all dimensions were reduced similarly to produce this reduction in displacement, the reduction would be in the ratio .933, which would make the length of the *Idaho* about 420 feet. As a matter of fact, the *Idaho* could be, and was, reduced in length to 375 feet without exceeding at 17 knots the limit for economical propulsion, and this reduction in length, an indirect result of the reduction in speed, was a very powerful factor in enabling the offensive and defensive power of the *Idaho* to compare so favorably with those of the vessel of nearly 25 per cent more displacement.

It may be noticed that Fig. 1 illustrates the fact that for vessels of the type under consideration the relative importance of fineness as regards speed increases rapidly with the speed. This fact has a very important result upon the dimensions of high speed battleships. As a practical proposition we cannot afford to make these vessels much longer than is necessary to carry their battery and machinery. Greater length would help somewhat as regards speed, but is forbidden by considerations of protection, handiness, and target area. We must gain speed by adopting the best possible lines and a fineness best adapted to the necessary and unavoidable length and the required speed. This means in practice greater fineness for high speed battleships. Now, with length and displacement fixed, we can gain fineness only by increase of beam or draft. For the near future the easiest and most obvious change is to increase draft. It is to be hoped that the apparently inevitable increase of size and speed of battleships will not compel

the naval architect a few years from now to make radical increases of breadth. Already dock entrances 100 feet wide look rather narrow for the most recent battleships building and designed. The present type of battleship is probably threatened to-day more than at any period of its existence by the submarine. If it survives the competition and is still the dominant type fifteen or twenty years from now, it seems to me quite probable that its maximum breadth will be found 50 per cent greater than at the present day—say 120 feet—unless considerations of sizes of docks and locks restrict the designers of the future.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

METHODS EMPLOYED AT TRAINING STATIONS FOR TRAINING APPRENTICE SEAMEN FOR THE FLEET.

By CAPTAIN A. C. DILLINGHAM, U. S. Navy.

The object of the training system is to supply the fleet from the training stations with fairly efficient men in the shortest possible time; to give such preliminary training at the training stations as will avoid the delay in getting a battleship ready for battle, as would result if raw recruits were sent to the fleet. From this, it is evident that the fleet is part of the training system, and unless the preliminary training at the training stations is perpetuated in the fleet, on board the fighting ships, the desired results (having, finally, able-bodied men-of-wars' men) will not be obtained.

It was found that the practice of taking very young, undeveloped boys into the service, for training, did not meet the requirements of modern fighting ships, where the weights to be handled, and the work to be done, are beyond the capacity of the very young, undeveloped lads. Also, that the system did not meet the requirement of supplying the fleet with men in the shortest possible time. This latter requirement was made more apparent by the shortage of enlisted force throughout the fleet, and the necessity for getting men as soon as possible, with new ships to be commissioned.

The Bureau of Navigation decided, that to meet these requirements, recruits, rated apprentice seamen, should be received into the service for the seaman branch, between the years of seventeen and twenty-five; that these apprentice seamen shall go through a preliminary course of training at the training stations, for a period of four months, at the end of which time, the apprentice seaman is rated ordinary seaman, and transferred to the fleet, where this preliminary training is to be continued.

The exception to this is the case of coal passers for the engineer's force, where any apprentice seaman who has aptitude for the engineer's force, who desires to enter that branch of the service, and who can pass the physical examination for that rating, is retained at the training station for a period of three months, at the end of which time he is rated coal passer, and transferred to the fleet.

The Bureau of Navigation has established a machinists' school at the Norfolk Navy Yard, the object of which is to afford the same opportunity to apprentice seamen and others entering the artificer branch (engineers' force) to become chief petty officers and warrant officers as is afforded those who enter the seaman branch; men with good records, holding the rating of water tender, oiler, or fireman first class, and having an average mark in both mechanical ability and knowledge of marine engines and machinery (taken from their enlistment records) of not less than 75 per cent, who are recommended by their commanding officers, are eligible upon re-enlistment for instruction in this school.

These conditions are carefully explained to the apprentice seaman before he elects the branch of the service he will enter.

There are other schools established for the professional education of enlisted men as follows: The Yeoman School, Artificers' School, School for Musicians, and School for Cooks, located at the Norfolk Station; the Gunnery Schools at Washington and Newport; Electrical Schools at San Francisco and New York. There is also a School for Hospital Apprentices, located at the Naval Hospital, Norfolk.

It will thus be seen that the Navy Department is fully alive to the necessity for the proper professional education of the enlisted man.

The fleet requires intelligent, able-bodied young men, who have had sufficient preliminary training to enable them to take care of their persons, their bags, and hammocks—to realize the military character of their chosen profession, and who have advanced far enough in professional knowledge to rid the commanding officer, in fleet, of the delay in getting his vessel ready for battle, that would be caused by receiving raw recruits.

Much has been written about the training of men for the naval service, and the systems of training employed by foreign naval powers have been investigated, to gain knowledge which might

be of use to us in training our own men. But the character and intelligence of the American recruit are such that he requires a system of training for his particular case. Formerly, the navy was recruited from the fishing fleets and the merchant marine, men who already had the sea habit; who had the sailor's trade, and who were accustomed to the discipline which exists on all well-regulated ships, whether of the merchant marine or navy. These men bettered their condition by entering the navy, and had only to learn the military part of their new surroundings and belonged to a class of men who generally speaking had no ambitions beyond the rate of petty officers.

To-day, most of our recruits come from the West, the Middle West, and the Lake Regions. And our navy has become such an institution in the land, that with the excellent system of recruiting adopted by the Bureau of Navigation, there is no difficulty in securing the enlistment of Americans, filling the requirements of the law.

Much embarrassment has been caused by not having a sufficient number of men in the allowed complement of the navy to meet the requirements of the fleet.

This shortage in the allowed complement is not caused by inability to enlist men, but by the sudden demand for a large number of men to fill the complement of new ships, going into commission.

If the enlisted force could be increased with each ship appropriated for, by the number of men necessary to man that ship, this embarrassment would disappear, and the excellent system of recruiting would supply the vacancies as they occur from time to time. The conditions to-day are abnormal, caused by the sudden demand for a large number of men to man the new ships added to the fleet.

In not allowing an increase in the complement for the fleet, an abnormal condition exists, which becomes more difficult as new ships are added to the fleet, and will reach a point where voluntary enlistments will not meet the demands of an efficient fleet, and there is danger, under present conditions, of reaching a point where only conscription will avail.

Under normal conditions, the number of desirable candidates is sufficient to meet the demands of the fleet.

Mention is made of this condition because it seriously affects the results to be obtained in the training service. With the short-

age of men for the fleet, it becomes necessary to draft men from the training stations before they have finished their preliminary training.

The recruit for the naval service, is, to-day, generally an intelligent young man, belonging to a highly respectable and important class of our citizens. He comes, usually, with the influence of our democratic institutions shown in his character, with very little idea of the military character of the business he is undertaking; all of which is perfectly natural when we consider that our country is not a military country.

Our navy is a military institution in a non-military country, and this condition is the cause of many of the difficulties we have to contend with; and not the least of these difficulties is found in trying to instill into the enlisted man, the military character of his calling.

For these reasons, and with the higher intelligence of our recruits, our training system must differ greatly from that of any other nation.

The best results are gotten at our training stations by making them absolutely military institutions, beginning with the recruit tactically, I may say; receiving him in a military manner, placing him at once in a tactical formation, and requiring him ever after to form, march, and be dismissed according to tactics. By this means, it is found that the tactical habit is very quickly acquired; the recruit prefers it; and the military character of his business is ever kept before him.

To illustrate this, I will say that at training stations, a recruit is received in formation, placed in a squad led by a squad leader; and he is always in the school of that squad, until he graduates into the fleet. His squad belongs to a section; and the section to a company; and his company has its own mess, quarters, and parade. His company commander and instructor is a chief petty officer, selected for his aptitude for that service; and in this organization he goes through the training station. The company petty officers being selected from apprentice seamen, and given acting appointments as they develop. These acting appointments make part of the record of the apprentice seamen having them. They go with their record to the fleet, and after inspection by the commanding officer in fleet, are returned to the owner.

This company belongs to a battalion, and that battalion has its

parade; and the battalion belongs to a brigade, and the brigade has its parade.

All instructors and drill masters are chief petty officers, selected for their aptitude for such duty, and are as follows: one brigade commander, one adjutant, one chief of company for each company. The instructors follow with their company or division through the entire course.

The detail of chief petty officers for such duty gives excellent results as a school for these chief petty officers.

One commissioned officer is detailed as supervising instructor of all formations and drills, and one commissioned officer as instructor in rifle practice.

Eighty men are taken into the division or company, as it has been found by experience that that number, with all absentees, for any cause whatever, will always give for all formations a tactical company.

At all formations—breakfast, dinner, supper, and for three drill periods—the squad is led to its section; the two sections form a company on the company parade. The company goes to the battalion parade, and the full brigade is formed, presented, and marched away, with full band and field music, time for not less than 120 steps to the minute.

It is found that this brigade formation can take place, and the units march off for whatever purpose in a much less time than could be done by any method not tactical. That requiring all units, of whatever size, to always march at not less than 120 steps to the minute, gives snap and vigor, and it very quickly becomes the habit of the recruit to step out upon all occasions in this snappy way.

At the Training Stations there are six brigade formations a day, with full band and field music. Each formation can be done tactically in about six minutes.

This method, with the strictest requirements of military etiquette, in the matter of salutes to all commissioned, warrant, and chief petty officers, gives excellent results in creating the military habit. The men entering the service to-day are not like the recruits of former days of the fishing fleet and the merchant marine; they are ambitious and not content to remain always in the lower ratings. In fact to-day, it becomes to the young man entering the navy, a business proposition, whether his future has better

possibilities in the navy or in civil life, so that in order to retain men permanently in the service, it becomes necessary for the navy to-day to compete with civil institutions.

Everything possible is done to convince the recruit that he has entered a profession which offers him such good opportunities for advancement that he has strong inclination to consider seriously making it a profession for life, but as the recruit spends but four months of his enlistment at the training station, there is left three years and eight months for the fleet to convince him that he will re-enlist; I speak of perpetuating in fleet the preliminary training at training stations. The training does go on in fleet, but it needs more than general training to get results from the apprentice seamen; they must be looked upon as our future continuous service men, and special training and personal supervision are necessary. Commanding officers and division officers should study the character and possibilities of each ordinary seaman and coal passer received from a training station, and the handling of these men should be with a view to encouraging them to re-enlist, for we *must* have a large continuous service force, around which may revolve the comers and goers.

Officers interested in the training system are waiting with great interest the reports from ships that have received from the training stations all their allowed ordinary seamen and coal passers.

The short time (four months) allowed apprentice seamen at the training station indicates that the Bureau of Navigation expects only a preliminary training at the station, and that this training shall be in detail, that which gives the best results in the given time.

To this end, the instruction is limited to subjects that the recruit can acquire in four months, and these subjects are given time according to their importance in preparing the man for the battleship training.

It should always be remembered that, generally, if you make a man comfortable and happy, you are going to get out of him all that is in him, and that there are ways of handling men so that you can get an immense amount of knowledge into them without their realizing any effort on their part. It should always be remembered in dealing with recruits that they should be favorably impressed with their calling, and that it is most desirable that men shall re-enlist, and remain in the service permanently.

In the matter of discipline at training stations, it is particularly desirable to study the individual character of the apprentice seaman, being careful to award punishments that will not degrade the man, or lessen his own self-respect, always remembering that the young man comes from a non-military life, and, above all, that he is an American. I have been two years in command of a training station, and have never found it necessary to place an apprentice seaman in irons. Such a punishment would be degrading to any self-respecting American. It is not desirable, at Training Stations, or in any other command, to have a classified list of punishments for the apprentice seamen, for a punishment that would accomplish the object and meet the requirements of the service in one case, might not be as efficacious in another case; the offense may be the same by name, yet the intent is entirely different, and the degree of guilt will vary.

It is not desirable to make deprivation of liberty a punishment, except where the offender has proved himself to be unreliable, and commits offenses when on liberty that he would not have the opportunity of committing were he deprived of liberty. Such cases are usually incorrigible and are best dealt with by discharge as undesirable. Courts-martial are resorted to at Training Stations only in case of crime.

There can be no fixed rule for inflicting punishments; in dealing with the recruit of to-day, it must be remembered that he is an American: that he is young and high-spirited, and generally unused to restraint; that the matter is discipline must be taught rather than inflicted.

It must be remembered also that the apprentice seaman is a young man, developing physically, and requires amusement and recreation. Young men, never used to discipline or military requirements, can very easily become disgusted and disheartened, and it requires tact to lead them through the training station so that they will realize they have made no mistake in coming into the navy.

At training stations, all drill and instruction cases at 3 p. m., and the last formation of the day is at 5 p. m., for supper.

Wednesday afternoon, Saturday, and on Sunday, after Divine service in the morning, the apprentice seamen are allowed boats for sailing and pulling excursions. This privilege for men from the interior of the country is considerable, and at the same time, gives instruction.

Apprentice seamen petty officers are allowed liberty on Wednesday p. m., Saturday, and Sunday; the other apprentice seamen, Saturday and Sunday. There is no restriction of liberty excepting for apprentice seamen doing extra duty.

At the training stations, we are now getting the most remarkable results by a system of what might be called "concentrated drills." To illustrate this, I will give routine of the drill period from 7.50 a. m to 9 a. m., known as the "Setting Up Period," which is done each day except Saturdays, Sundays, and holidays.

At 7.50, the brigade is formed, under arms, presented, and the following evolutions take place, after having saluted the colors at 8 a. m., viz.:

Brigade on line; distance taken to the front; arms grounded; step left; physical drill without music; take flags (small flags stowed in the leggings when not in use); semaphore drill, with music; return flags; step right; take arms; physical drill, with arms, to music; arms grounded; at ease, to straighten belts, etc.; to rear assemble; manual of arms; all firings; squads right; change direction to the left; column of companies; right by sections; form company square; flankers right and left into line, double time; form company; companies left; companies right; squads right; companies column left; change direction to the left; companies left front into line, double time; sections, right and left turn, double time (street riot); form company; form company square; form column of sections; squads left; sections, right front into line; column of companies; close in mass; take full distance; street column; form square; street column; column of companies; line of squads on ( ) squad; brigade, halt; as skirmishers; rally by squads; as skirmishers; rally by sections; as skirmishers; rally by company; as skirmishers; assemble by squads; assemble by companies; companies left; dismiss.

This period is a daily routine. It would be foolish to put the recruits through the school of the battalion, or brigade, but the results gotten from this period in company, battalion, and brigade movements, from the mere force of habit, are remarkable for precision and tactical correctness. The recruit, in exercising his legs, had better do tactical movements.

Excellent results have been gotten from "concentrated drill" with boats. After the men have been instructed individually in the boats, the boats moored head and stern in line—sixteen of

them—the drill begins; and together, they perform everything that is done under oars; also step masts together; make sail together; shorten sail together; furl sail together; unstep masts together. This is proceeded with until finally the eight lee boats are sent out under oars, and the eight weather boats under sail, every other sailboat forming a division, and getting under way separately, for drill under sail.

At the Norfolk Station there are sixteen cutters hoisted to davits on the dock. At low water, when the distance to be lowered is considerable, a very excellent concentrated drill is had in lowering these sixteen boats together. It is probable that we will always have on the modern ship some boats to be lowered by hand, and it requires no little skill to lower a boat properly. It is probable that we will always have lifeboats ready for lowering. At this station, we have two lifeboats, fitted in all respects according to regulations, the gripes and other appliances for the boat having been made by the apprentice seamen; the apprentice seamen are exercised in the lifeboat service; at the last inspection, lifeboat crews from a division picked at random were able to pick up a dummy man, thrown in the water at some little distance from the boat, the lifeboat was down, man picked up, and lifeboat hoisted again in less than two minutes, the dummy man was properly placed in the boat, and afterwards, the means for restoring the apparently drowned applied.

I can say in the matter of boats that the apprentice seamen at this station stand ready to compete with any boats' crews in the fleet, for good pulling, handling boats under sail, the boat habit, and with the lifeboat.

Frequent regattas are had in pulling and sailing, prizes for which are supplied by the ship's store.

There are three steam tenders attached to this station, and the apprentice seamen detailed daily for these tenders march from breakfast aboard, get under way, and return in time to march to supper. During the cruising of these vessels, the apprentice seaman con, steer, handle lead and log, and carry on signalling, and the apprentice seamen intended for coal passers perform their duties in the fire-rooms. The chief petty officer in charge of the company is always with his men on board these tenders. Each tender is in charge of a warrant officer.

The tenders cruise each day except Saturdays, Sundays, and holidays.

I give these examples of methods employed at training stations to show that in the short time of four months, it is possible to train men so that at the end of that time, they will be ready to commence their battleship training.

It would seem to be a fact that if the commanding officer can receive ordinary seamen and coal passers who have qualified on the target ranges, and have been through the training attempted at our training stations, that much time will be saved in having his vessel ready to join the flag, and in getting ready for battle, and that it would seem hardly possible to supply the fleet with fairly efficient men in a shorter time than by the present system of training of recruits. The climax of efficiency of the enlisted personnel will be reached when we have a large enough continuous service force to man our fighting ships, with the vacancies as they occur supplied by the ordinary seamen and coal passers who have been through the preliminary training at our training stations, and by men who have passed successfully through the other service schools.

The highest efficiency of the fleet will thus depend upon a large continuous service force, and an efficient training system. And it should be the serious endeavor to obtain this condition.

The methods and details are identical at all training stations so far as the climatic conditions will allow.

Below is given a list of subjects arranged consistently with the importance that a knowledge of each has in producing the desired results:

1st. Cleanly habits: the care of the person and the contents of bags and hammocks, which necessitates frequent rigid inspections.

2d. Physical development; setting up drills. This is carried on as explained for the "Setting Up Period."

3d. Qualifying on the target ranges with revolver and rifle, according to the firing regulations. If men go to ships in commission qualified in the firing regulations, much time is saved aboard these ships where the facilities for small-arms practice are few, and the opportunities for such practice not frequent.

4th. Battleship seamanship, which includes steering; compass; lead and log, both hand and patent; boats under oars and sail; lowering boats and lifeboats; marlin-spike seamanship; splicing

and manipulating wire rope; knotting and splicing wire rope and Manila rope; bending hawsers; handling hawsers, wire and rope, for towing, fasts, etc.; carrying out anchors; ground tackle.

In the modern ship, few men are found who can do a sailor's job, such as working wire rope; for this reason, great care is taken, and considerable time is given, to have apprentice seamen go through a thorough course in this subject.

5th. Signals, comprising all the codes in use in the navy.

The semaphore is taught at setting up, where the man, using small flags, goes through the code to music, and also at divisional instruction.

Young men are usually much interested in signalling, and find much pleasure in being proficient. They acquire this knowledge very quickly, and become very expert.

Appliances for signalling are at the disposition of the apprentice seamen, at the proper hours, day and night.

6th. Ordnance: Lectures in the simplest form upon kinds of powder used in the service, shells, fuses, guns, etc.

Morris tube work is not attempted at the training stations, but there is at the Norfolk Station a 5-inch gun, fitted with the appliances for Morris tube work, and this gun is at the disposition of the apprentice seamen, and is used by them for amusement. A gunner's mate is always on hand to explain the use of the gun, and supply ammunition.

Many apprentices become very expert in the use of the Morris tube, and make excellent scores.

As the motion is given to the target by an electrical apparatus which gives accurately any degree or any period of roll, the apprentice seaman has nothing to do but to handle the elevating and training gear.

Company, battalion, and brigade drills. Once a week, the brigade is exercised in "battle drill," a section of artillery being the enemy. At this drill, a field hospital is established, and the aids to the wounded are exercised.

The daily routine at the Norfolk Station is given below:

"CAMP ROUTINE."

5.15 a. m....Call officers on duty, bugle squad, chiefs of sections, and squad leaders.

5.30 " ....Reveille (buglers marching through camp). Roll up tents (if weather permits) and make up cots.

5.45 a. m.....Two divisions to march in to baths, remainder of brigade strip and wash to waist, and scrub clothing.
6.40 " ....First call.
6.45 " ....Assembly (march in to breakfast).
7.30 " ....Police tents, streets, and surroundings. See that everything is neatly stowed—chief of sections will attend to this—seeing that each squad leader looks after the tent of his squad, and will report when finished to their company commanders, who will report after an inspection to the brigade commander about 9.00 a. m.
7.45 " ....First call.
7.50 " ....Assembly.
7.55 " ....Adjutant's call (first period).
8.45 " ....Sick call.
9.00 " ....Second inspection of company tents and streets and report of same.
9.15 " ....First call.
9.20 " ....Assembly and inspection of men by company commanders.
9.30 " ....Adjutant's call (quarters and second period).
10.45 " ....Retreat from drill and reports to mast. Scrub clothing.
11.35 " ....First call.
11.40 " ....Assembly.
11.45 " ....Adjutant's call (march to dinner).
1.10 p. m.....First call.
1.15 " ....Adjutant's call (third period).
3.00 " ....Retreat, scrub clothing, and recreation.
4.35 " ....First call.
4.40 " ....Assembly.
4.45 " ....Adjutant's call (march to supper).
5.40 " ....Swimming call.
5.50 " ....March swimming party to float.
6.45 " ....First call.
6.50 " ....Assembly (for muster), (posting of sentries).
8.55 " ....First call.
9.00 " ....Tattoo.
9.05 " ....Taps.

The camp must be habitually kept clean, and ready for inspection at any time from 7.30 a. m. until 6.00 p. m.

Sentries in company streets will be held to account for the actions of cooks, men on sick list, etc., who are left in camp while the brigade is at drill.

Sentries will at no time allow visitors in camp. They will be governed by the general orders relating to sentries, a copy of which will be found on order board in petty officer's tent.

Company officers will assure themselves that their men thoroughly understand their duties when posted as sentries.

It is found best not to compel apprentice seamen to scrub or wash clothes at any regular or routine hour, but to allow them to

scrub and wash clothes at any time that does not interfere with drills and formations. The recruit knows that his bag must be ready for inspection at any time, and that clothes worn must be clean.

Oftentimes men turn out in the morning, and do not feel up to scrubbing clothes. They may not feel well, and to be obliged to scrub clothes, particularly when you have not been used to such a thing, and when you are not feeling very well, makes the recruit liable to shirk cleanliness.

The general mess system is employed at training stations, and the bill of fare for this week will indicate that the recruits are well fed, viz.:

U. S. R. S. FRANKLIN.

BILL OF FARE FOR WEEK COMMENCING NOVEMBER 25, 1906.

SUNDAY.

Breakfast..Boiled eggs; oatmeal; sweet milk; bread; butter; coffee.
Dinner....Roast veal; brown gravy; sage dressing; lima beans; sweet potatoes; bread; fresh fruit; coffee.
Supper....Cold sliced ham; mustard; bread; butter; plain pound cake; tea.

MONDAY.

Breakfast..Boston baked beans; tomato catsup; bread; butter; coffee.
Dinner....Pea soup; boiled salt pork; mustard; pickles; bread; coffee.
Supper....Canned corn beef; fried potatoes; bread; butter; fresh fruit; tea.

TUESDAY.

Breakfast..Fried pork chops; fried onions; bread; butter; coffee.
Dinner....Cold sliced ham; boiled cabbage; boiled potatoes; mustard; bread; coffee.
Supper....Fried liver with bacon; brown gravy; mashed potatoes; bread; butter; fresh fruit; tea.

WEDNESDAY.

Breakfast..Fresh mutton stew; tomato catsup; hot rolls; butter; coffee.
Dinner....Roast beef; brown gravy; boiled potatoes; sweet corn; bread; coffee.
Supper....Steamed frankfurters; sauerkraut; bread; butter; fresh fruit; tea.

THURSDAY.

Breakfast..Boiled eggs; bread; butter; coffee.
Dinner....Roast turkey; chestnut dressing; giblet gravy; creamed potatoes; sweet potatoes; celery; oysters; oyster crackers; green peas; olives; cheese; fruit cake; mince pie; ice cream; apples; grapes; oranges; bread; coffee; cigars.
Supper....Cold sliced Smithfield ham; bread; butter; fruit; tea.

FRIDAY.

Breakfast..Boston baked beans; tomato catsup; bread; butter; coffee.
Dinner....Fresh vegetable soup; boiled beef; boiled peeled potatoes; bread; fresh fruit; coffee.
Supper....Fish croquette; tomato sauce; bread; butter; canned fruit; tea.

SATURDAY.

Breakfast....Fried pork sausage; tomato gravy; bread; butter; coffee.
Dinner....Roast beef; brown gravy; mashed potatoes; lima beans; bread; coffee.
Supper....Fresh beef stew; dumplings; bread; butter; fresh fruit; tea.

It will be seen by the above routine that the apprentice seamen at this station are in camp.

It being necessary to extensively repair the tentative barracks at this station, and for sanitary reasons, the apprentice seamen were put in camp, and have been in camp for the past eight months.

The camp is arranged strictly according to tactics, the men being housed in hospital tents—each tent fitted with a tent stove.

The camp is five minutes' march from the mess hall.

This experience of having the apprentice seamen in camp instead of in barracks has been valuable, and the results have been so satisfactory in the matter of health, and the facilities for properly supervising the apprentice seamen, that it is proper to consider whether it is not best in latitudes where men can be drilled out of doors all the year round, to put them in camp, under canvas, without ever using barracks.

In temperate climates, it would seem from the experience at the Norfolk Station, that the great advantages of camp life from a sanitary point of view, in being able to care for the health of the men, warrants the consideration of establishing our training stations in temperate localities, giving the apprentice seamen quarters in a properly constructed camp, where it would require in addition only a mess hall and its appurtenances, and a recreation hall.

Statistics at this station will show that there has been little or no sickness since the apprentice seamen have been quartered under canvas, whereas, while in barracks there were always the usual diseases, incident to the living together of a great number of men.

The consideration of this subject is foreign to this article, but as it has had much to do with the training of men at the Norfolk

Station, inasmuch as I believe it has preserved their health, I have thought it of interest to mention it.

The great point in getting the best results at training stations, is being able to properly supervise the units of the organization. This comes second only to the preservation of health. Both of which can be accomplished better in camp than in barracks, provided the climate will permit.

With the liability of sickness in barracks, it is most difficult, when contagious diseases occur, to properly segregate the men. Contagious disease in barracks requires the fumigation of the entire barracks, and proper medical treatment of the entire building. In camp there is much less liability to disease, and sanitation is very easily accomplished. The mosquito can very easily be excluded, and for sanitary reasons, a tent can be destroyed without great loss of money or housing facility; the trouble of proper supervision is reduced to a minimum, and there is an attraction about the camp life to a young man which does not exist in barracks.

To have a proper camp of course requires the space, and that the surface ground be properly drained. There will not be the slightest trouble in heating each tent with steam heat, lighting the camp with electricity, and permanent floors could be made of cement.

To my mind, the camp is ideal for the training station located in a temperate climate.

Extensive barracks need not be erected in such a climate, as the only buildings necessary would be the mess hall and kitchen, water-closets, and recreation and drill hall for rainy weather.

Considering the battleship to be the proper training ship, the hearty co-operation of the fleet with the training service, should give good results.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

TEAM RIFLE SHOOTING.

By LIEUTENANT HARRIS LANING, U. S. Navy.

That the Navy Department is desirous of bringing small-arm target practice in the navy to a higher standard is shown by the building of fine ranges, by a recent change in the general scheme of small-arm practice, and by the giving of a trophy to the ship on each station that develops the best rifle team. This last will tend to develop team shooting in the navy and will throw the responsibility of developing teams on officers who have had little or no experience in the work. Having had the same responsibility put on me during the past year by being the coach for the Naval Academy Rifle Team and the captain and coach of the Navy Rifle Team, I feel that some of the things I have learned may be of service to others who have the same work to do. So far as I can learn, very little has been written about team shooting, and while there are many excellent books on how to develop the individual shot there doesn't seem to be any that gives more than the merest outline of team work. I do not put this forth as more than a mere starter on the subject, for my experience is not great, but only as a slight aid to the team captains who will be in the dark as I was when I took up the work. Therefore such information as I have I wish to give to others, not only that they may have the advantage of it but that they may improve on it. If, however, it helps any of the captains of our service teams in the trophy competitions I will feel that it has served its purpose.

I do not intend to go into the details to be found in the many books on rifle practice. A book recently published by Lieut. Townsend Whelan, U. S. Army, "Suggestions to Military Riflemen," which I hope will soon be found in all ship's libraries, treats of rifle shooting for the individual. It starts with the selection of a rifle and carries a man to the conditions on the battle-

field. I will assume in this article that all the points to be found in Lieut. Whelan's book are known to all officers in charge of teams; as the knowledge contained therein is essential to success in teaching rifle shooting of a high order. A team captain knowing those things can teach them to the individuals on the team, but team work is more than the work of individual men,—it is the work of a number of individuals working as a unit. To attain that team work I wish to start the team captain at the point where Lieut. Whelan drops him.

THE COMPOSITION OF A TEAM.

In the National Team Match and in the matches to be held between ships, a team is composed of twelve principals (the men who actually fire) three alternates, a spotter, a team coach, and the captain. The principals do the firing. The alternates are on hand to take the place of a principal who on account of sickness or injury cannot continue the match. The spotter's duties are to watch the target and the score board to see that the score is correctly kept and aided by a powerful telescope assists the captain and coach by watching the flight of the bullets, the point of fall, etc. The duties of the coach are to assist the captain in coaching and training and to give any advice he may think will help the team. Many captains do the coaching themselves, but if a good coach is available he can be of inestimable value in helping the captain. The team captain commands, instructs, and coaches the team, his authority in the team being final. A team properly and carefully organized is necessary in order to get the best results.

THE CAPTAIN.

The first step in developing a team is the choice of a captain. A good captain for a rifle team is as necessary as a good officer for a crack division. To select a man for captain because he has but little else to do is certainly inadvisable. The officer who is best suited to the work should be chosen. He must, first of all, be enthusiastic over the work otherwise the steady grind will become a dreadful monotony and there will cease to be interest in the team. He should be a man of force, tact, good nature, and, above all, a hard worker. It takes as much study, longer training, and more sacrifices to develop a rifle team of the first-class than

it does a foot ball team of the first-class, and the man chosen for team captain must realize it and take the team well knowing what it means. A captain requires tact to always keep the team in friendly spirit, he requires a good disposition to keep from undue and unnecessary fault finding, and he requires determination to keep himself and his men going when everything seems to be going wrong. In addition, a team captain should have a good knowledge of shooting for unless he knows he cannot teach. He should be or should have been a good shot, but he should not, under any circumstances, fire on the team as he will have all he can possibly do if he makes a good captain. A team captain well chosen is a long step toward winning a match.

THE COACH AND SPOTTER.

The captain should next choose his coach and his spotter in order that they may assist him in all his future work. The term coach is usually applied to the expert shot who knows all about fine rifle shooting, but who for some reason is not eligible for team captain. Such a man is hard to find in the navy, but a junior officer of promise may be given this billet and by his work aid the captain very materially. The experience the young officer will get will be of great value to him. The spotter should be a man of strong eyesight, well versed in the rules of shooting, and especially developed to " spot " for the team. He should be either a junior officer or a petty officer and if a good man he can give great assistance especially in studying conditions and in watching the bullets in flight.

THE EQUIPMENT.

The captain, coach, and spotter having been selected and having become thoroughly familiar with the principles laid down in Lieut. Whelan's book, the equipment should next be looked out for. The care and completeness with which the captain selects his gear will mean much to the success of the team. The selection of good rifles is perhaps the most essential thing of all, for no amount of training or skill can overcome the handicap of poor shooting guns. About thirty of the very best rifles available should be set aside for the team. I suggest thirty rifles as the minimum number in order that there may be one for each candidate for the team and a few extra to take the place of any that may not shoot well. The following is a list of the other articles required:

1 cartridge belt for each man.
12 verniers for setting sights.
1 sight cover for each man.
4 telescope (officer of the deck type).
4 pairs of tripods for holding telescopes.
1 powerful telescope on tripod.
1 aneroid barometer.
1 thermometer.
4 blank books recording practice scores.
√4 cleaning rods 42" long..
√50 yards of canton flannel (cleaning rags).
√1000 soft lead bullets, Winchester 32-20.
√1 small oil-stone slip.
√2 small flat files.
√1 small hammer.
√1 micrometer calipers, reading to one ten thousandth of an inch.
√3 packages wax tapers for blackening sights).
√1 reamer and 1 file (watchmaker's) for enlarging peep sights.
√12 sheets emery cloth.
1 long rifle sling for each man.
1 good score book for each man.
36 brass wire cleaning brushes.
8 rifle rests.
2 pairs binoculars (high power).
1 hygrometer (reading in per cent of moisture).
1 stop watch.
Ammunition (same kind and date as match ammunition).
1 blank book for data ("Dope" book).
√1 gal. of nitro-cleaner or Hopp's mixture.
√⅛" screw driver.
√½ gal. sperm oil.
√½ pint fine lubricating oil.
√2 small triangular files.
√1 3 lb. weight (for testing trigger pulls).
√12 sheets sand paper.

If possible a small wagon should be obtained to carry the equipment from point to point on the range. This wagon makes an excellent rack for holding the rifles when not in use. There should also be a number of camp stools for the use of the captain, coach, and spotter, and for members of the team when not firing.

The above seems like an enormous amount of gear, but each article is necessary and if used properly is bound, in the long run, to help out the team's score.

Some place on board ship should be used as a workroom for the team and be accessible to them at all times. It should contain a suitable work bench fitted with a bench vise and all the tools should be kept there for the use of the team. A good rifleman grows fond of his good rifle and will do better work with it if he is allowed to adjust it himself, providing sufficient instruction has been given him to keep him from ruining it. All the articles on the above list marked √ should be kept in the work room.

To each candidate for the team will be issued: 1 rifle, 1 sling, 1 belt, 1 sight cover, 1 score book and pencil, and 1 cleaning brush. As there are but 12 verniers these should be issued one to each

pair of men and care should be taken that during the entire shooting season a man always uses and records the readings with one vernier as the verniers do not all read alike.

The following articles should be carried around to each firing point in the wagon:—Team score books, "dope" book, pencils, hygrometer, thermometer, barometer, binoculars, all telescopes and tripods, rifle rests, some wax tapers, ammunition, 1 cleaning rod, cleaning rags, cleaning mixture, and camp stools. As soon as a firing point is reached the gear used by the firers should be put in place. At the longer ranges for each pair of men firing at one target there should be placed: 1 telescope (if available there should be two, one for each man) with its small tripods, and two rifle rests (one for each man). The spotter rigs his large telescope and gets his score sheet ready. The team captain and coach get their books and instruments ready. (I have estimated on enough material so that four targets may be used at once at any range. The use of more than one target at a range is necessary if more than two or three ranges are to be used in one day.)

From the foregoing it will be seen just where each of the articles mentioned in the list is used. Just how they are to be used is fully explained in Lieut. Whelan's book.

SELECTING THE CANDIDATES.

Having at least arranged to get the equipment together, the team captain should next begin to gather his men. While among the undeveloped shots on board there may be some excellent material, there will probably be but little time to develop it and the best thing to do will be to take the best twenty-four shots in the crew, as shown by the small-arm records, and develop them. In choosing these twenty-four it will be well to use care not to get men who will get tired of the training, for the training will be arduous. Then, too, it is best to select only those men who are sober and reliable, for the others are apt to fail one during an important match. Men of quick temper, especially those who curse at every bad shot and blame the rifle and markers, should be soon dropped from the squad. A man who gets "fussy" over a bad shot is more than likely to stay "fussed" and will turn in a bad score. It is better to select the men who, when they get an unaccountable shot, will try

to find the cause of it and remedy it. The fault is usually to be found and simply "blowing up" will only lessen the chance of finding it. The men chosen must be the men who are always working in the team's interest and the men who will best do this are the men who will implicitly obey the orders of the captain and his assistants. Any man who fails to carry out his instructions should not be considered for a place on a strong team, for that man is apt to be the weak link that makes a break in the chain of strong team shooting. Besides a man who fails to follow instructions teaches other men to do the same and hurts the team in that way.

The twenty-four men best fulfilling the above conditions should with proper care and training make a strong team. I suggest twenty-four candidates simply as the minimum number a captain should start with. If time permits many more should be tried, but there should never be less than twenty-four as a man gains his most valuable experience in competing for a place on the team.

TRAINING THE CANDIDATES BEFORE GOING IN THE RANGE.

Most of the good shooting organizations of the United States have many men who have learned the principles of good range work and in such an organization a team is easily selected and can begin to do team work at once. Unfortunately for the navy the general knowledge of high class shooting is mostly limited to the few men who have been in training for the Navy Rifle Team. If there are many others I do not know of them. We must, therefore, develop our individuals for individual work as well as team work.

The candidates selected should at once be given their rifles and taught how to put them in first-class condition and keep them so. Sights should be carefully cleaned and made to suit the eye, trigger pulls should be adjusted, upper and lower bands looked after, slings properly adjusted, stocks well oiled and cared for, and in fact all the details that will improve the rifle must be looked out for. These things can be done on board ship and several days spent on the work will be well spent for somehow a man seems to shoot better with a piece he has worked over for a while.

In order that a team captain may know how to adjust his rifles, I will give here briefly what is done to the piece. This is more fully explained in Dr. Hudson's book, "Modern Rifle Shooting from the American Standpoint."

First, take off the stock, being very careful not to mar or bend the barrel. With the barrel out adjust the trigger pull. This is done in two steps. It will be noticed, in pulling the trigger, that there are two distinct steps in the pull. The first of these is a long drag as if pulling against a spring. After a considerable movement of the trigger, a harder pull is felt after which a very little movement of the trigger fires the piece, this short hard pull being the second step. The long and heavy pull found in new rifles is a big handicap to good work and it should be changed into a short, smooth, and light pull. To eliminate the long drag of the first

TRIGGER.

SEAR.

step, take out the trigger and sear and file down the trigger bearing (marked C in the sketch) until the heel (D) will rest against the bottom of the receiver. Next the short hard pull that comes just before the firing pin is released is reduced and made smooth. This is done by grinding down the nose (A) of the sear to keep it from entering the notch too deeply. After the nose is ground down it should be smoothed on an oil-stone. Great care must be used in grinding the nose down not to take off too much, for if too much is taken off the piece may not always cock, especially in rapid fire, or the pull may become too light. The test for the first of these is to lift the hammer smartly, while the piece is cocked, to see if it can be released from the sear in that way. If it can the limit of safety has been passed as it has also been if the 3-pound

weight hung on the trigger releases the sear. In either of these events the toe (T) will have to be ground down to allow the sear to go in further. In order to make the trigger pull just right it is necessary to put the trigger, sear, and bolt in place frequently and test the trigger pull both with the finger and with the weight and also by lifting the hammer. Considerable care and patience must be given to this, but if given a fine pull will result. Of course every working surface should be made smooth on the oil-stone before assembling the parts.

There is another and much easier way of improving the trigger pull and that is by "blocking" the trigger and smoothing the nose of the sear on the oil-stone. Although a "block" is very easy to put in, it is not certain to remain in position and it seldom gives as smooth a pull as the other method, but where time is limited it is the only thing to do and then, too, with green men the piece is not so apt to be injured as it is not necessary to take the stock off to block the trigger. Get a piece of an old hack saw blade, cut it down to a length of about one inch, smooth off the teeth, and draw the temper out of it. Then take the trigger guard off the rifle and lay the rifle on the bench trigger up. Put the small piece of steel just forward of the trigger in the recess for the trigger guard, then pull the trigger slowly and carefully until it just comes up to the second or hard part of the pull. Hold the trigger in that position, slip the block up tight against it, then put the trigger guard back in place and screw it down hard. The block will then be jammed between the wood of the stock and the guard, and will prevent the trigger from going forward, thus cutting out the drag.

While the stock is off the gun, that the sear may be smoothed down, it is well to take the opportunity to oil the grove in the stock that the barrel fits in. The oil should be rubbed in with a rag and then the grove and recesses given a coat of vaseline. The oil and the soft vaseline will sink into the wood and make it water tight so that when water gets under the barrel the stock will not warp.

Next re-assemble the piece, but do not put the upper and lower bands in place permanently. It is essential that the bands be just tight enough to hold the barrel to the stock closely and no more. If they are put on tight while the barrel is cold, they will bind very tightly when the barrel expands from the heat of firing, and

as the barrel lengthens from heat while the wood does not there may be a slight buckling of the barrel which increases from shot to shot, especially in rapid fire, and causes erratic shooting. Therefore, before putting the bands on, file the wood under them down until the bands just make a nice fit when slid on by hand. This fitting should be done carefully and after being done should be tested from time to time, particularly in wet weather, to see that they are not too tight. Remember that unless the barrel is free to lengthen itself by sliding under the bands it is almost certain to shoot erratically.

The piece now being assembled, attention should next be given to the sights. See that the front sight is straight and remains so. Then take off the rear sight, see that there is no oil or dirt under it, clean the sliding surfaces of the fixed and movable base, and wipe off and clean the sight itself. Then put the sight back in place, setting up tightly on the screws. If the sight seems loose it may be that the screws are too long for the holes. The end of the screw should be filed off and tried until they go all the way home and hold the sight firmly. Before screwing them in permanently it will be well to immerse the screws in salt water, for they will then corrode in place and will be sure to hold the sight in place always. No good shooting can be done with a loose rear sight and once in its proper place it should remain there at least for that season's shooting.

The sight now being rigidly attached to the rifle, the sliding leaf must be put in proper condition. The leaf should fit the bar closely and when the set screw is tight the leaf should have no play whatever. If a leaf does have play it should be replaced. The leaf being a good fit, attention is next given to the peep hole. Most of the peeps as issued have a very small hole and are a great strain on the eye. While a few men prefer a small peep hole others can do far better with a large one and so a peep should be adjusted to suit the man's eye. To enlarge the peep properly the hole should be reamed out from the side toward the muzzle and should be conical in order that the edge may be a knife edge and that the light may get to it from both sides of the leaf to make it show up clearly. A small file handle ground off to the proper angle makes an excellent reamer for the metal of the leaf is very soft. Great care must be taken to keep the tool straight while reaming out the hole or the hole will become elliptical or rough.

After having reamed the hole out from the back of the sight, see that there are no burrs on the front of the leaf. If any are found they should be smoothed off with a rat-tail file. In boring out the peep holes use care not to get them too large, finding by trial just what size the man needs.

The working parts of the rifle should next be taken out and cleaned thoroughly until all parts are smooth and free from dirt. The parts should then be oiled with a good machine oil. Next take a rag saturated with raw linseed oil and rub all parts of the stock thoroughly with it. The object is to get the stock perfectly water tight so that moisture cannot get into it and warp it. Stocks are easily warped and a slight warp will bend the soft barrel of the rifle and cause erratic shooting. Then adjust the sling so that it will properly fit the man who is to use it. A sling improperly adjusted may be more of a nuisance than a benefit.

A rifle carefully gone over as explained above should, if was selected for the quality of its bore, etc., give excellent results.

Having put their rifles in good condition the men are ready for their minute instruction in how to handle it. As nearly every man in the navy has been taught to use the open sight, the first work should be to teach the men to use the peep sight. The peep sight seems to be much more accurate than the open sight, especially at long ranges, and it is usually much easier to teach men to use it than to teach them to use the open sight properly. The men should therefore be told all about the peep sight and the use of the vernier for setting and adjusting it. They should be thoroughly drilled in keeping their private score books and in how to use the records they keep in them. The proper use of a good score book is absolutely essential to consistent good shooting, so the greatest care should be taken to teach men to use it. The candidates should next be given position and aiming drill daily. This not only teaches them how to aim and how to pull without deranging the aim, but also tends to develop the muscles used in firing so they will stand a hard day's shooting without tiring. This is a monotonous exercise, but will be of great benefit if carried out systematically. While these exercises are being carried out daily, each man using his own rifle so as to get used to the feel of it and to his trigger pull, it will be found advantageous to give each man some training each day in each position at the sub-target gun, as with it the faults in holding, aiming, and

pulling can be discovered and corrected. At the same time by adjusting the sub-target gun a man can be made to simulate practice at any desired range and by making the man adjust the *sight* to bring the prick of the needle in the bull's-eye he can be taught how sight adjustments are made. Also by using the score book in connection with the sub-target gun a man can, to a large extent, learn the correct use of the score book. In this training all corrections should be made by adjusting the sight instead of adjusting the scales on the machine.

At this time, too, the men should be thoroughly instructed in skirmish work,—what it is, and in detail how carried on. They must be told just when in the run to adjust their sights, when to load, how to take the positions quickly, how to aim at the figures, in fact, complete instruction in the rules and methods of skirmishing. If possible a skirmish group should be set up on shore, in a space sufficiently long for a short run, and the men given some practice runs over it, using dummy cartridges, to see that they understand what the run really is and what they must do in the run. Men will learn to skirmish quicker if they know the principles of skirmishing thoroughly.

Most of the training spoken of above can be done on board ship and all of it can be carried out before going on the range. A good team captain will have done these things thoroughly before going on the range, for on the range time is too valuable to waste in teaching fundamentals especially as they can be taught better on board ship. If, after the preliminary training is finished, a gallery is available it can be used with great advantage.

TRAINING THE INDIVIDUALS ON THE RANGE.

After a few weeks of careful instruction and training along the above lines the candidates should be in good condition to take up actual work on the range. It is well to have the men thoroughly understand that a good shot is a man who consistently makes good scores at all ranges and under all conditions. A remarkably high score now and then with poor scores in between does not make a man a good shot. A man who has a fair average made by consistent scores is better for a team than a man whose average is the same or even better but who has his off days and shoots badly. Such men frequently get their off day the day of the match and the team's score suffers. The men should therefore

strive for consistency and should be encouraged to use every fair means of attaining it. Any man who resorts to unfair means to get on the team weakens it, and a man being detected in unfairness should be dropped at once.

When the firing starts, watch each man closely and coach him to correct his remaining faults. Some men do not take kindly to this coaching, but if handled properly will come around all right. A little tact and much care not to antagonize the men will do a great deal toward making the coaching easier. But the coach must finally have his way, and when all the team find that by giving the coach his way better results are obtained, they will always do as he tells them without question. The coach should get close to the men and work with them and the men must work with the coach, for in this way team feeling and team spirit is developed, and team spirit will often make a team fight its way to victory in the very face of defeat.

It is at this stage of the training that the men are taught the ways of judging the conditions and how to use the conditions to the best advantage. As all team shooting is done in pairs, the men firing shots alternately, and coaching is allowed between men in the pairs, it follows that if each man not firing can coach his mate who is firing, that a great many points can be gained for the team. Therefore, each man should be taught how to watch the flags, the mirage, or other indications of the wind, how to watch the light for changes, and to caution his mate how to fire, how to change his sights, and when to fire. To master these things requires long practice, but having mastered them a team is many points ahead of equally good shots who have not. Each man should be taught to do these things so that he can properly coach any man he may be firing with. Some men when firing with a rival for a place on the team have been known to coach him off the target instead of into the bull's-eye. Should this be discovered the offender should be dropped from the squad at once, for unless men have implicit faith in each other's advice the great gain from coaching in pairs is lost. This feature of team shooting cannot be too well developed for it is the real groundwork of high class team shooting.

At the same time that the men are being instructed in the slow fire work certain parts of each day should be devoted to the rapid fire and skirmish features. The rapid fire at the shorter

ranges offers but little chance for team work, although careful noting of the windage corrections by the first men will often help the succeeding men. The greatest attention should, however, be given to skirmish fire for it is in the skirmish that a team will make its greatest gain or greatest loss. Individual skirmishing is the most practical shooting a man can have and collective skirmishing is just as practical and involves many men firing as a unit. The men having thoroughly learned the lessons given them before going on the range are familiar with what is expected of them on the skirmish run. The first thing to be done is to let the men get their elevation for each range. The quickest way to do this is to put the figures on the sliding frame of the 600-yard targets and to have markers in the pit to show the location of each hit by using a spotter. Starting at 600 yards, each man slowly and carefully fires single shots, each hit being indicated by a spotter as soon as made. Be careful to caution the men to aim at the figures just as they do at the bull's-eye and to aim just as carefully. Good holders will soon find a sight bar elevation that will make them hit the kneeling figure in about the middle. This elevation should be carefully recorded and will be the elevation ordinarily used at 600 yards in the skirmish run. Then go to 500 yards, 400 yards, and 350 yards, getting the elevation for each range in the same way. At 300 yards and 200 yards elevations are found for getting a hit in the prone figure about six or eight inches from the bottom. Each man should get these elevations very accurately, record them in his score book, and mark them on the stock of his rifle so that he can see them quickly when running and will not depend on his memory. With these elevations the man is ready to make a run. In the regular skirmish run there is no marking of shots and a man has to depend on his own observations to tell whether he is hitting or not. Therefore, teach the men to fire the first shot accurately and then to note just where it hits, so that if it misses the figure the next shot can be brought on by "holding" for the error. The man should endeavor to see the "dirt" of the first shot at each range except at 200 yards where the time limit is short and wild shooting is rare. The man should also be taught to watch the wind carefully while making the run and to change his windage from range to range. As there is not time to touch the sights between "commence firing" and "cease firing" at any range, great care

must be used to teach the men how to "hold" to correct a bad shot. This is one of the few cases where men have to hold off the mark. The men should also be drilled to set the sight *accurately* at the elevations found, for unless the sights are accurately set the shots will be misses. It takes a great many runs to make men good skirmishers and know all the tricks. Every few days, even if skirmishing regularly, the men should be given the opportunity of checking their elevations by trying them just as they did in getting them.

After some practice along these lines at all the ranges, a certain number of men will have shown forth as particularly good shots, others as fairly good shots, and others as poorer shots. But we must always consider as a part of a man's shooting ability his other ability to coach his mate. A fair shot who can coach a mate into a big score will do more for the team's score than will a better shot who coaches a mate into a poor score. In other words, a man may be a few points better in himself and a great many more points worse to his mate. The man whose scores are the highest is not always nor even often the best individual shot on the team, but is the man who has been best coached by his mate. So it does not pay to always choose men on scores alone for in proper team work the highest scores will always come from the men who are coached best. Some teams selected on the mere shooting ability of its individuals and who fail to coach each other are far outshot by teams of less individual ability who do coach. Therefore, in selecting the men who are to be dropped be sure to consider whether these men have had as good coaching mates as have the others. Taking these things into consideration the captain can now reduce his squad to eighteen men and this should be done as soon as possible in order that too much time may not be wasted on men who cannot possibly make the team.

SELECTING THE TEAM.

The squad now being smaller, we begin the real team work. Having due regard for the holding ability of some men and the coaching ability of others, the squad should be arranged in pairs. The twelve men who seem most likely to get on the team should be paired off first. In arranging pairs do not put two good coaches together if by doing so two poor coaches come together, for two poor coaches will lose far more points than the two good

coaches can gain. At least one man in each pair should be a good coach, for if necessary he can coach for himself although he will probably soon bring his mate nearer to his own standard of coaching. But while making this arrangement do not put men together who are antagonistic, for, however good they may be the antagonism will hurt their scores. And yet because two men are chums should not of itself make them firing mates.

Next consider the order in which the pairs will come on the firing line. It is necessary that the first pair up, and especially that the first man of the pair to fire, be the best on the team. The first man to fire must be the man best able to judge conditions, the man best able to find the target if his first shot misses, and the man least likely to be disconcerted by a string of misses. His mate should be an excellent holder and also a fair judge of conditions. This pair should be followed by two good shots who will do just as they are told to do, for such men usually make good scores, and if the first four men get good scores, the next four, among whom are the weaker shots, will no doubt do well. The last four men and especially the last two should be the "work-horses." They are the steady, nerveless men, who no matter what the strain is can shoot and shoot well. On them, in a close match, often hangs the result and their work then may turn apparent defeat into victory.

These twelve being arranged tentatively, the others are paired so as to put the better coaches with the weaker ones. We are now in a position to develop the team as a whole. It should not be made known who the men likely to make the team are for it is in the practice at team shooting that the places yet doubtful are filled. Let no man be sure of a place on the team at this stage, but make him always remember that the final selection will not be made until the last moment.

TRAINING THE TEAM IN SLOW FIRE.

Up to this point the work, though of the utmost importance, has been monotonous and wearing. But as the team is now organized the captain and coach come to the front as the minds that govern the team unit. It is in this stage that they see the results they have worked for begin to crystallize, and from this time the work is very interesting, and, to those who like it, almost fascinating. While training the individuals, the "dope" book should

have been carefully kept and will begin to be of assistance at once, but the real value of the "dope" book is in the data put in it from this point on.

A "dope" book is a memorandum book used for keeping a complete record of the data of each man's firing at the different ranges. It should be strong, well bound, and of good paper. All data kept in it must be very accurate, for inaccurate data is worse than useless. The book should contain, in the front part, all the necessary tables such as the changes in height of impact in inches on the target for a change of 25 yards in sight-bar reading at each range used; the change in inches laterally made by changing the windage one point at each range used; the difference at the various ranges, in height of impact between the first shot from a clean, cool, rifle free from oil and subsequent shots; a windage table showing the number of points to the right or left the sight must be set to correct for wind of any velocity up to 20 miles from the different points of the clock; a similar table for corrections in elevation due to wind with and against the bullet; the exact dimensions of the various targets used; and a summary of the thumb rules to be used in regard to the effect of light changes, mirage, and changes in barometer, thermometer, and hygrometer. While some of these rules and tables will soon become well-known, nevertheless it is well to have the correct data at hand so as to avoid errors.

Following these tables should come the data of the men themselves, one page being given to each man. This should contain the man's name, the number of his rifle, the number of the vernier he uses, a table showing the results of the calibrations of his rifle made at different times, his windage zero, his normal elevation for each range, and any special notes on the man's firing peculiarities. This last should include the effect of changes of light on the man. Men seem to be effected differently by changes of light and each man should be carefully watched when changes occur until it is found how such changes effect him. A note should be made of it and the man coached carefully to correct at once for changes when they come. When firing under difficult light conditions the knowledge of the effect of changes will often save the match.

The "dope" book should next be divided up into sections of say twenty pages each and one section assigned to each range

used in the match. At the top of each page should be a place for the date, the time of day, the reading of the barometer, thermometer, and hygrometer, the force and direction of the wind, the atmospheric conditions in regard to haze, the conditions of light, and the kind of ammunition used and its date. The data for a day's shooting at any range should be entered on one of the pages set aside for that range. Under the heading should be a blank form in which the names of the men are placed in the order that they fire and in columns opposite the names spaces in which to enter;—score at that range, elevation (by vernier), windage used (in points), force of wind, direction of wind, hygrometer and thermometer reading (if changed from top of page), and in a column headed "Remarks" notes made concerning the string (such as changes in light, mirage, or any change in conditions). All the data must be carefully entered and absolutely correct. Such a table is made out each day at each range used and from these tables the team captain gets the corrections he must apply to one man's elevation and windage to get the correct elevation and windage for another man. Thus if (A), the first man to shoot, gets in the bull's-eye, the captain can find from his data what correction to apply to A's readings to get the correct readings to put (B) in the bull's-eye. From these tables he finds the normal elevation for each man at each range and how much this elevation is changed by a change in conditions. Knowing a man's normal elevation at any range and wishing to find the proper elevation for the first shot at that range on any day it is only necessary to apply in succession the corrections for light, hygrometer, thermometer, barometer, and windage, and the captain can tell at once what sight readings the man should use. He can also tell approximately, if the shot misses, what to do to bring the next shot on. Using this method of getting his first pair on the target he can tell from his data what corrections for the readings of the first pair are to be applied to get the correct readings for the second pair and so on. In high class shooting every point counts and a team cannot afford to lose any by neglecting these means of making the *first* shot in every string a good one. In getting this data the team should if possible use ammunition of the same kind and date as is to be used in the match, but if this is impossible the match ammunition should be thoroughly tried out and the change in normals between the two kinds noted. This

change is a constant correction to be applied to the practice elevations to get the elevations for a match.

Firing the team through the entire course to be used in the match while collecting and using the data as explained above, soon develops the team to its state of highest efficiency. In the first few days firing under the match conditions the team's total scores will probably be less than was hoped for, but as the days pass and the coaching and the use of the "dope" become more efficient the scores will grow larger. Too much driving at this stage gets men on edge too quickly and they may be deteriorating when the match comes off. In this event to continue hard shooting will hurt the team and a rest must be taken. It hardly seems possible that this can happen in the short time a ship's team will have for practice, but it should not be overlooked as a possibility. The team should not fire over 70 or 80 shots per man per day as too much shooting hurts both the man and the rifle.

In firing the team through the match course, great care should be exercised to see that the rules of the match are exactly carried out. If they are not the chances are that the men will, when in the match, be greatly disconcerted by having to do something apparently out of the ordinary. This is especially true in regard to the time limits.

It may be well to note here that in firing through the course it will be found that the team is good at some ranges and poor at others. At the ranges where the team is weak there should be considerable extra practice. The usual points of weakness in all teams are in the long-range work, rapid-fire work, and skirmishing. At the short ranges a great deal of extra practice fails to increase the score very much, while less extra practice will show big gains at others. More time should then be paid to that firing where the greatest gains can be made, which in slow fire is at 800 and 1000 yards. An amount of training that will raise a team's score at 200 yards by 24 points, will if put in at 1000 yards raise the score there by 50 or 75 points.

TRAINING THE TEAM FOR RAPID FIRE AND SKIRMISH.

In the above I have dealt mostly with slow fire at fixed ranges, but most of the important matches now have both rapid fire and skirmish firing and for these a great deal of training is necessary. Rapid-fire work is too well-known in the navy to call for any de-

tails here, but as lack of practice will make the rapid fire score low it must not be neglected. And remember also that too much rapid fire cuts the rifling out of a rifle. Very large gains or losses can be made by a team in one skirmish run so the team should be developed to *always* make a good skirmish.

To get the best results from a team in skirmish fire requires the same care and study that long-range work does. For all team firing the men must know the "zero" of their rifles perfectly and this is especially true in team skirmishing so that every man may be able to at once set his sight for any lateral correction given by the team captain. The team must also have and know the *correct* normal elevation for each range used in the run and should be able to quickly adjust the sights for exactly these elevations. (The correct elevations should be written on the piece.) The men should know at just which ranges they are to fire at the kneeling figure and which at the prone. Each man should be given a regular place in the team line and the runs always made with the men in their regular places. The best holder and the man who can be relied on to fire the first shot at the long ranges quickly and accurately should be placed in the center of the team, for the captain follows and spots the shots this man fires and coaches the entire team from them. A description of what is done on the run will explain the scheme of team skirmishing. Just before the team is called to the firing line the captain (and coach) carefully gauge the conditions and calling the team together give them the windage and tell them what change (if any) from the normal elevations is required. The team then *carefully* set their sights for the first range and take their places on the line when called. When the team gets on the first firing point and the signal to commence firing is given, the center man, who has been carefully trained for this work, fires his first shot immediately, the rest of the team waiting for the word of the captain before they commence. The team captain, who is right behind this man, watches the fall of this shot and sees if he has made the correct allowances for wind. If he finds he has and the line is good he sings out "good" so that all the team can hear and they commence firing, confident in their wind correction. For success in the use of this scheme, the "dirt" from the first shot *must* be seen. If the butt is such that the "dirt" behind the target, made by a shot that hits it, cannot be seen, then the center man must fire so as to get the

"dirt" in front of and just under the target. If the center man should happen to get a bad pull he immediately says to the captain "pulled right (or left)" and the captain must then judge if the windage he gave is correct. If the "dirt" shows that the windage is wrong, that is if it hits to one side of the point where it should have hit, the captain sings out "(so many) feet left (or right)" and the team will have to aim that distance to one side of the figure to be sure of hitting. While this method will usually insure most of the shots hitting, yet every man must make it a point to see the "dirt" his first shot makes and if it is not a hit he must "hold" for the next shot so that *it* will be. The time limit of 30 seconds in which to fire the two shots at the 600-yard and 500-yard lines gives ample time to use this method at those ranges and it should always be done when the team runs. From what he has learned at 600 yards the captain is able to judge the wind more closely for 500 yards. As soon as each man fires his shots at 600 yards he immediately sets his sight for the 500-yard halt, the captain ordering any necessary corrections. During the advance the captain watches the wind closely and finding any change gives the correction for it just as the team gets to the next line. The few seconds allowed before "commence firing" gives the men time to carefully examine and see that their sights are correctly set. When "commence firing" is sounded the center man again fires first and the captain passes the word to the team. After leaving 500 yards the time limit will hardly allow this scheme to be used, but by that time all are probably "on," nevertheless the captain must still continue to watch the wind and keep the men posted on that. In regard to the windage to be used when firing at the prone figure at the shorter ranges, it is well to remember that windage to the left of the real windage is to be favored there, because the prone figure is higher on the left side and a high shot on the right will go over the back while a high shot on the left will go through the head.

The number of shots to be fired at each figure of the group on the run is determined by the captain. Some teams, usually only the very best, fire the shots from 600 and 500 yards at the kneeling figure and all the rest at the prone figure. Others shift to the prone figure when the 350-yard line is reached thus firing 7 at the kneeling and 13 at the prone. Others shoot ten and ten, shifting to the prone at 300 yards. For teams that make many

misses in the run the kneeling figure is none too large, but a good team must get every possible point and the captain must determine by trial which plan brings in the best score with his team. When the light is bad the prone figure is often hard to see at the longer ranges so, that, on the day of the match the captain must consider the light conditions before deciding.

In all skirmishing some of the shots will miss and a reduction in the number of misses increases the team's score. It therefore behooves the captain to find at just what ranges a man gets his misses, and where the shots go so that the correct change can be made in the sight-bar reading for those ranges. With a good holding team misses are usually the result of having the wrong elevation. While the method I gave above is very useful in getting the first elevations it is often not quite good enough for getting team elevations, for some men actually sight differently in slow and rapid fire. As the skirmish elevations are for rapid fire work each man should frequently get a test of his elevations to see that they are right. The best way to do this is to have a man make a regular skirmish run using three groups of targets. He fires at the kneeling figure of the right group at 600 yards, at the kneeling figure of the middle group at 500 yards, at the kneeling figure of the left group at 400 yards, at the prone figure of the left group at 350 yards, at the prone figure of the middle group at 300 yards, and at the prone figure of the right group at 200. In this way he will have a separate target for the shots fired at each halt. Sitting at the 600 yards, behind the man running, is the spotter with his big glass and a skirmish target score sheet. The spotter indicates on the score card the exact fall of every shot fired. The man skirmishing should make a note of any bad pulls he has on the run. After the run he goes to the targets and finds and records his hits. Taking the data of the spotter and the score sheet turned in by the man, the captain can at once see where the misses have occurred and where the shots went. He can then tell the man what corrections he will have to make. It is advisable to check elevations frequently in this way, for with sights incorrectly set good shots will never get a hit. With a very poor shot, elevations need not be so accurate as a poor holder will get more hits with a wrong elevation than a good holder will.

In the match the total hits made by the team count and no

attention is paid to individual scores. For that reason, if in a team skirmish one man's targets are indistinct he should at once fire at one of his mate's targets that show up well. Again, in a run, if a man's target is knocked down the man should at once fire at his neighbor's. Any target belonging to the team may be fired at, but be careful that the men do not fire at your opponent's target, as that will simply add to their score. Coach your team not to work for individual scores but to work for the team total in the match.

THE FINAL MAKE-UP OF THE TEAM.

Firing the eighteen men now in the squad through the match course and strictly under the match conditions a number of times, the team captain can decide just who the best men are to put on the team to fire in the match and he should have the selection made some days before the match. The fifteen men who make up the principals and alternates may be told that the team will be chosen from among them. It may develop while firing through the match conditions that the twelve men originally paired off for the team may not all be in the line-up finally decided on. If one man shoots himself into team form and another originally selected as a team man fails, the new man should at once be put in his place so that the pairs may be used to each other when the match comes. During the last few days the alternates should be fired with the various men on the team as mates in order that they may not be ignorant of the methods they will meet if, for some reason, they are put in to shoot. The fifteen men thus trained and developed certainly ought to do well in any match they enter.

THE MATCH.

On the day of the match the exact line up of the team is announced. Call the team together, tell them just what is expected of them, and caution them again to make the best possible out of every shot from the first to the last. The men firing, however, are not the only ones who have work in the match for the captain and coach have to do their part too. They must not only urge the team on at all times, but must in their own work show the spirit, determination, and skill that is expected from the men. They must look out for every contingency and with their knowledge and good advice lift the men over the hard places. Care-

lessness and neglect of their own important work in "doping" the men will work great havoc with the team's score. They, too, must fight to the end, for many a big match is won in the very last shots fired.

RULES FOR CONDUCTING MATCHES.

Matches are of course shot under various rules. The National Board for the Promotion of Rifle Practice (a body created in 1903 by an Act of Congress) has drawn up regulations governing the National Matches and these regulations are taken as a criterion for conducting all matches. As these rules are not usually accessible to officers of the navy they are herewith added for the information of those interested in rifle matches.

RULES AND REGULATIONS FOR SMALL-ARMS COMPETITIONS, PREPARED BY THE NATIONAL BOARD FOR THE PROMOTION OF RIFLE PRACTICE.

(Published under the authority of the Secretary of War.)

The following regulations have been agreed upon by the National Board for the Promotion of Rifle Practice, appointed by the Secretary of War under authority of an act of Congress, for the national match and other team competitions, individual matches, etc., and will, by direction of the Secretary of War, govern accordingly:

1. OFFICERS OF THE COMPETITIONS.—The officers of all competitions shall consist of—

(*a*) An executive officer.
(*b*) An assistant executive officer.
(*c*) A post adjutant.
(*d*) A post quartermaster.
(*e*) A statistical officer, with as many assistants as may be necessary.
(*f*) As many range officers as may be necessary or as may be detailed for that purpose.
(*g*) A post surgeon.

2. OFFICERS' DUTIES.—The duties of the officers shall be as follows:

Executive officer.—The executive officer will have control of the range for the conduct of the matches, and his decision shall be final.

The executive officer may, in his discretion, upon the certificate of the post surgeon, permit the substitution of an alternate member of the same team in place of one who may be taken ill during the shooting.

Assistant executive officer.—The assistant executive officer shall report to and receive instructions from the executive officer and assist him in the management of the competitions.

Post adjutant.—The post adjutant shall discharge the duties of adjutant to the executive officer, issue by direction of the executive officer the necessary orders, and perform such other duties as may be assigned to him.

Post quartermaster.—The post quartermaster shall have charge of the issue of stores and supplies to the competitors, and discharge such other duties as may be assigned to him by the executive officer.

Statistical officer and assistants.—The statistical officer and his assistants will assign the competitors to targets and to order of firing, their determinations being generally by lot. They will verify the additions of the scores as reported by the scorekeepers, grade them in order of excellence, and prepare the results for official announcement.

In all meetings where a number of men engage in the same matches or competitive firing, the labor of the statistical officers will be greatly lightened, and the prompt announcement of the score facilitated, by giving to each competitor a number by which he will be known throughout the firing, if practicable.

Range officers.—The range officers will supervise the marking and scoring; they will see that the competitors do not evade any of the regulations; they will test the trigger pull of and examine at any time the rifles used by competitors; they will inspect the ammuniton before the beginning of all matches; and they will certify on the score cards to the scores made, after verifying same with the blackboard.

In individual matches the range officers will certify to the date, hour, and style of arm in the entry ticket of competitors about to begin their score, and when the score is finished they will certify to the same on both original ticket and coupon. The latter they will tear off and deposit in the scorers' box, returning the original to the competitor.

In team matches the range officers will, at the completion of the score at each range, verify the scores on the score card with the blackboard and see that they agree. When the matches are finished they will add up the totals, certify to the correctness of same, and return the card or cards to the statistical office.

During the shooting of all competitions a range officer shall be detailed to the pit at each distance, who shall remain in the pit until the firing at that distance is finished. Range officers shall be chosen, as far as practicable, from distinguished marksmen, expert riflemen, sharpshooters, and officers experienced in range work.

The range officer in charge of the firing point must witness any alteration of a score card and must indorse the alteration with his initials.

A range officer desiring to be relieved from his post of duty will report to the executive officer, so that a substitute may be detailed.

Post surgeon.—The post surgeon shall have charge of the health and sanitary condition of the camp and rifle range, and shall perform such other duties as pertain to his profession.

Officers must report.—All officers of the competition will report to the executive officer at his headquarters each morning at 8 o'clock, or such hour as he may designate, when they will be assigned to their several stations and given their badges.

The post adjutant, post quartermaster, and post surgeon will be on duty continuously at headquarters.

3. RULES FOR PITS.—In team matches one representative from each team must be selected by the team captain at each distance (before the drawing of the targets at that distance), who shall receive from the executive officer a card directing him to remain in the target pit during the firing at the distance about to be begun. The representatives from the various teams in the target pit will call the attention of the range officer on duty in the pit to any irregularity of marking or other matter deemed by them necessary, and the decision of the range officer in the pit as to the matter complained of will be final and binding. This provision is mandatory and must be enforced.

Rapid fire.—In rapid fire, time is regulated at the target, the signal at the firing point being given as a warning to the range officer in charge of the pit that all is ready at the firing point for the target to appear.

Procedure.—In rapid fire, with rifle or carbine, at the disappearing target, the range officer in charge of the target, at the signal from the firing point, commands "Ready." As soon as all is in readiness to run up the target he commands "Up." At exactly the proper number of seconds after the target is in position he commands "Down," having preceded this command two or three seconds by the warning command "Ready." The target must be exposed and withdrawn as quickly as possible. The number and value of the hits are signaled with the usual disks in the usual manner after the score has been fired, the number of misses being carefully indicated by the flag as a check on the accuracy of the number of hits signaled.

When the single rolling, or Cushing, target is used, the method of marking will be varied to meet the conditions.

Pistol—In rapid fire with the pistol at the disappearing target the manipulation of the target is as in rapid fire with the rifle or carbine, except that the target remains exposed the number of seconds called for in the match.

4. RULES FOR FIRING POINTS.—*Slow fire.*—During the progress of a match or competition, no one except the officers on duty at the range, the competitors and scorekeepers will be permitted within the ropes without special permission of the officer in charge.

Five yards in rear.—The squads of competitors will be stationed 5 yards in rear of firing point, where each competitor must remain until called by the scorekeeper or range officer to take his position at the firing point and until he has completed his score.

All expression on the part of the competitor of approbation or disappointment, with reference to any scores made by himself or others, must not be uttered loud enough to be heard at the firing point.

Competitors present punctually.—Competitors must be present at the firing points punctually at the time or in the order stated on their score cards. No application on the part of a competitor for an alteration of his assignment will be entertained, except that team captains may change the order of firing of the members of their teams if they so desire.

Order of distances.—In competitions or matches embracing more than one distance, the slow fire will be commenced at the shortest distance and be followed in order by each of the longer distances, the firing at the longest range being held last.

Squadding.—In individual matches that are squadded, the squadding of the competitors will be done before the beginning of the match.

Fire alternately.—In team competitions the competitors, will place themselves at the firing point by twos and fire alternately, the odd number of each pair being on the right and firing first.

Target withdrawn while firing.—In slow fire, if, just as the shot is fired, the target is withdrawn from the firing position, the scorer at that firing point will at once report the fact to one of the range officers, who, if upon investigation is satisfied that the case is as represented, will direct that the shot fired be not considered and that the competitor fire another shot.

Time limit.—In slow fire, competitors will not be hurried in their firing, but such slight delay permitted after each shot as they may desire; provided the time of firing the total score with rifle and carbine does not exceed an average of one minute per shot for ranges of 600 yards and less, and of one and one-half minutes per shot for ranges above 600 yards, no time credit being allowed.

If an accident to a target, or any other cause over which the competitor has no control, prevents him from completing his score within a reasonable interval, he will be permitted such additional time as a range officer may decide.

Drawing targets.—Targets in fixed-distance team firing will be drawn at each range by team captains at the executive officers' headquarters.

Coaching.—In team matches no coaching or communication of any kind with men at the firing point will be permitted except by the team captain, and then only for the sole purpose of preventing infractions of the conditions of the match, except that the competitors actually firing may communicate with each other.

When competing for the Dryden Trophy, or in other special team matches, coaching is authorized.

Position of captain, etc.—In team matches, at least 3 yards in rear of each firing point, there will be permitted one team captain, one coach, and one spotter, who may observe the firings of the members of their team and check the value of each shot as called by the scorer. The captain, coach, and spotter shall not be permitted to shield a competitor from the wind, throw a shade upon his sight, or aid him in any other way.

Positions.—The following positions only will be permitted in competitive firing: At 200 yards, the standing position, the body and arm being free from any artificial support; at 300 yards, sitting or kneeling; at 500, 600, 800, 900, and 1000 yards, prone, with head toward target.

Strap.—The use of the strap as a sling will be permitted at all ranges, provided it is attached to its proper swivels and is used only in connection with the arm of the competitor as a brace.

Loading arms.—No arms shall be loaded except at the firing point, the

muzzle of the rifle, carbine, or revolver being kept in the direction of the target until the arm is either discharged or unloaded.

Rapid fire.—Target: F.

Procedure.—The magazine is filled, one cartridge loaded therefrom, and the piece then held at position "Ready." At a signal given at the firing point (trumpet or telephone) the target appears, remains in sight twenty seconds at 200 yards, then disappears. No sighting shots will be permitted. The competitor attempts to fire five shots, emptying the magazine and firing at will, without command, from the instant any portion of the target appears until it has completely disappeared. Each unfired cartridge counts as a miss. In case of a defective cartridge or disabled piece the practice is repeated.

Challenges.—If a competitor desires to challenge his shot just fired because of failure of any record from the pit, such challenge will be sustained and the record from the pit given without cost. If a competitor in the national match, or other team matches, desires to challenge his shot just fired for alleged incorrect marking, he must pay $1. If the competitor's challenge is sustained and it is shown that the marking was incorrect, the money will be returned to him. All money paid in fines as prescribed in this paragraph will be turned over to the treasurer of the organization conducting the match.

5. PROTESTS.—Protests and objections must not be directly submitted to the executive officer, but to one of the range officers. In case a competitor considers the decision of the latter unwarranted by the facts as presented, he may appeal to the executive officer. Final appeals from decisions of the executive officer must be made in writing and forwarded through that officer to the executive committee of the National Rifle Association or the association under whose auspices the meeting is being held. In national contests an appeal may be taken to the national board authorized by act of Congress, etc., whose decision shall be final.

6. SCORING AND MARKING.—Hits in the different divisions of the targets and ricochets will be signaled and recorded as prescribed in the Small-Arms Firing Regulations. Ricochets count as hits.

Spotter.—The exact location of all bullet holes will be marked by a spotter, which will be shown on the target.

All shots fired count.—All shots fired by the competitor after he has taken his place at the firing point, and it is his turn to fire—the target being ready—will be considered in his score, even if his piece is not directed toward the target, or is accidentally discharged.

Shots upon wrong target.—Shots fired upon the wrong target will be entered upon the score of the man firing as misses.

Two hits on target.—In slow fire, if two shots strike a target at the same or nearly the same time, both will be signaled, and if a shot was just fired from the firing point assigned to that target, the hit having the higher of the two values signaled will be entered in the competitor's score, and no record made of the other hit.

Value of shot, change of record.—Competitors must pay attention to the score as announced and recorded, so that any error may be promptly investigated. The record value of any shot will not be changed after the following shot has been fired, unless some special message with reference to it is received from one of the range officers in the target pit.

Sighting shots.—In all matches two sighting shots at each range, slow fire, must be taken. Whenever, because of a storm or for any other reason, the executive officer shall postpone an unfinished match, two sighting shots will be allowed on the unfinished score of each man when the match is resumed.

7. DUTIES OF SCORERS.—The scorekeepers will be seated close to and in the rear of the firing-point stakes, and will, as each shot is signaled, announce in audible tone the name of the competitor, the value of the shot, and number on score card, marking same on the blackboard and competitor's card. At the conclusion of the score of each competitor the scorekeeper will repeat his name and total score, and request the range officer on duty at that target to verify the blackboard and score card (no scores will be allowed unless recorded on a blackboard by the scorer as shot). All scorers will be supplied with field glasses. The executive officer will prescribe the manner and form for all telephonic communication between firing points and pit.

8. SKIRMISH FIRE.—In skirmish fire, after the run is completed and the signal "Cease firing" has been sounded and repeated twice, the markers will examine the targets, the range officer will record the total hits on each, and the results will be communicated by means of prepared score cards to the statistical officers. In this fire the precautions with regard to the use of a red pencil in marking shot holes will be observed.

In skirmish competitions by team, targets will be drawn by team captains. In all other skirmish competitions targets will be drawn by competitors immediately preceding the commencement of the runs. No communication will be held between the skirmish pit and the firing line and no scores will be brought out of the pit or published until all runs are completed.

The aggregate value of all shots in all the figures of the groups will be the team's total for the run.

Team captain may coach.—In skirmish competitions by teams the teams will run under the command of a range officer, but a team captain may coach his men on the run. One or more range officers will accompany each team to see that the conditions of the match are not violated.

Twenty cartridges.—In skirmish fire twenty cartridges will be issued before each run to each competitor, and the latter will not be permitted to have any other cartridges about his person. If any cartridge fails to explode it will be replaced by the scorer with a new one.

Disabled gun.—If a gun becomes disabled from any cause the incomplete score will be counted and the competitor will not be allowed to repeat the run. This applies to all matches. Hits, direct or ricochet, will be scored.

Individual.—In individual skirmish competitions no two competitors from the same team shall be allowed to skirmish on adjoining targets.

Target and value of shots.—In skirmish competitions the group target "G" will be used, one group for each skirmisher. Targets placed in line, with intervals of not less than 5 yards between centers of groups. The value of shots: Hit, direct or ricochet, on lying figure, 5; kneeling, 4; miss, 0. Hits on the black silhouette only will count.

Procedure.—In skirmish competitions each competitor will fire twenty shots, 600 to 200 yards. Six halts at the following distances: 600, 500, 400, 350, 300, and 200 yards. At all distances, with the exception of the 200 yards the time limit will be thirty seconds, and at the 200 yards twenty seconds. Any authorized position for firing will be permitted.

A squad of convenient number is formed in line opposite the targets at a distance exceeding 600 yards; twenty rounds of ammunition per man are issued; magazines are filled and cut off, and, in accordance with Infantry Drill Regulations, the line is advanced in quick time to the 600-yard firing line. Here the line is halted and each skirmisher, without further command, takes one of the authorized positions and at the preparatory command for firing loads his piece from the belt. At each range except 200 yards there shall be an interval of at least twenty seconds between "Halt" and "Commence firing;" and at 200 yards at least 50 seconds between the same commands. In national matches the trumpet will sound "Halt," "Commence firing," and "Cease firing."

The commands for firing are: 1. *Fire two rounds,* 2. *At 600 yards,* 3. *At the targets,* 4. COMMENCE FIRING. After the command of execution the firing opens at will and each skirmisher fires two rounds within the time limit of thirty seconds, the piece being used as a single-loader. At the expiration of time limit the command "Cease firing" will have been given.

The firing having ceased, the advance is resumed and continued to the 500-yard firing line, where two rounds are fired in the same manner as at 600 yards; the advance then continues to the 400 and 350 yard firing lines, at each of which three rounds are similarly fired, and then to 300 and 200 yards, at each of which five rounds are fired from the magazine. The time limit at 200 yards, it should be noted, is twenty instead of thirty seconds, as at the other halts. Commands, in all cases, conform to the Infantry Drill Regulations.

Quick and double time.—The advance between 600 and 200 yards will be, between any two successive halts, the first half at quick and the second at double time; and it is enjoined upon the range officer to see that the double time is maintained as nearly as possible according to Infantry Drill Regulations, i. e., length of step 36 inches and cadence 180 steps per minute. The firing is completed at 200 yards.

Rifles loaded at halt only.—Pieces will not be loaded during the advance, but only at the preparatory command for firing after a halt.

Time limit.—The time limit extends from the last note of "Commence firing" to the last note of "Cease firing." The range officer will see that the signals are properly sounded, not permitting the last note of "Cease firing" to be unduly prolonged.

Penalties.—For each shot fired by the competitor before the commencement or after the close of the time limit, or for each shot fired in excess of the number ordered for the halt, five points will be deducted from his score. Five points will also be deducted for a failure to fire the number prescribed for a halt.

Defective cartridges.—A defective cartridge may be replaced by a file closer, but must be turned in before the advance is resumed. The substituted cartridge must be fired, if at all, at the halt where the misfire occurred and before "Cease firing" shall have been sounded.

Competitors will not be permitted to advance nearer than 200 yards from the targets.

More than twenty hits.—When in individual competitions more than twenty hits are found in a group target, the score will not be counted and the competitor will make another run.

Muzzle toward targets.—In this class of fire the muzzle of the rifle must be pointed toward the targets when marching or at the halts.

9. ARMS.—*Team matches.*—In all military matches the following arms only will be used, unless otherwise provided for in special conditions:

The United States Army magazine rifle and carbine, .30 caliber.

Individual matches (not exclusively military).—The rifles and carbines allowed in competitions are as follows:

(*a*) Any military rifle.

(*b*) Any rifle.

They must comply with the following conditions:

Any military: Any military rifle that has been viewed and stamped by the National Rifle Association in accordance with the resolution heretofore adopted for this purpose by the National Board for Promotion of Rifle Practice, as follows:

Resolved, That rifles of private makers, conforming in all respects to the following:

(*a*) The piece must be capable of using the standard Government cartridge;

(*b*) It must be the same length and weight;

(*c*) It must be fitted with a sight similar in design to one of the standard military sights as adopted by the War Department;

when viewed and stamped by the National Rifle Association, shall be permitted to be used by clubs duly affiliated with the National Rifle Association for qualification as national marksmen and in matches where the rules permit any military rifle.

Any rifle: No restriction as to weight, caliber, sights, or trigger pull, except that rifles with less than 2 pounds trigger pull must be provided with safety lock.

Sights (military rifles).—The aiming notch, or the aperture of the slide, may be slightly widened or opened to accommodate individual peculiarities of eyesight, but no other alteration or filing of the regular service sights, or the use of spirit levels, will be permitted. The front or rear sights may, however, be blackened according to the judgment of the competitor. The use of permanently affixed micrometers, orthoptic eyepieces, telescoptic

sights, spirit levels, temporary shades, or any other device will not be allowed, unless specially provided for in the conditions of the match.

Competitors in the National Match or the National Individual Match may use field glasses or small telescopes, such as might reasonably be carried to the field as a part of a soldier's equipment. They may also use a micrometer and small individual score book. They will not be permitted any other aid or device at the firing point.

Trigger pull.—The trigger pull must always be at least 3 pounds, and will be tested (holding the barrel vertically) by a range officer, before firing, each day and at each range.

Competitors will submit their arms for further inspection whenever required.

Changing rifles during matches.—No two competitors shall shoot in any competition with the same rifle, nor shall a competitor change his rifle during any competition unless his first rifle has become unserviceable through an accident, which must be verified by a range officer.

Fouling.—No firing, except at the targets or in a warning or fouling pit, will be permitted under any circumstances. Any violation of this rule will disqualify the competitor from further participation in the meet.

Cleaning.—Pieces can only be cleaned upon the completion of a score. In competitions at more than one distance cleaning will be permitted between distances. While, with these restrictions, cleaning will be permitted, it will not be required. Cleaning will be allowed between shots when it is so specified in the conditions of the match.

Handicap.—In all team and individual matches the carbine will be allowed a handicap of 4 per cent at 600 yards, 6 per cent at 800, 900, and 1,000 yards.

No handicap will be allowed unless noted on score card by a range officer. Competitors must see that this is done.

10. AMMUNITION.—Unless the use of other ammunition is distinctly authorized, the ammunition used will be the service cartridge for the arm, as manufactured and issued by the Ordnance Department.

11. UNIFORM.—Military competitors will wear the service uniform, with or without blouse and with the belt.

12. PENALTIES.—No two competitors shall in any match or competition use the same rifle, unless it is a special condition of the match, nor shall a competitor change his rifle during any competition, unless it has become unserviceable, which fact must be verified by a range officer. Wilful violation of this regulation will warrant the executive officer (in his discretion) in excluding the competitor from further competition.

Any person, whether a competitor or not, interfering with any of the firing squads, or annoying them in any way, will be warned to desist, and if he repeats the offense he will be at once ordered off the range grounds.

Any competitor—

(*a*) Who shall fire in a name other than that under which he entered, or who shall fire twice for the same prize, unless permitted by the conditions of the competition to do so; or

(*b*) Who shall be guilty of any conduct considered by the executive committee to be discreditable; or

(*c*) Who shall be guilty of falsifying his score or being accesory thereto; or

(*d*) Who shall offer a bribe of any kind to any employee or other person; or

(*e*) Who shall be detected in an evasion of the conditions prescribed for the conducting of any match; or

(*f*) Who shall refuse to obey any instructions of the executive officer or a range officer; or

(*g*) Who shall be guilty of disorderly conduct or being intoxicated, shall, upon the offense being proved to the satisfaction of the executive committee, forfeit all his entrance fees, be forever disqualified from competing at any time in the meetings of the Association, and shall not be entitled to have any prize won by him at the time of meeting awarded to him.

Unauthorized ammunition.—Any competitor having any ammunition in his belt or about his person when he takes his place at the firing stand, other than that authorized, will be immediately disbarred, and his score will not count for record.

13. ENTRIES.—Competitors who make entries for any match will be ruled out and will forfeit their entrance fees if not on the range at the hour designated for the match.

Entry tickets must be marked with the purchaser's name at the time of the purchase; they may be transferred to another name with the consent of the executive officer; any erasure or substitution of a purchaser's name on a ticket, not made by the statistical officer, will forfeit the ticket.

Post entries.—All entries made in individual matches after the opening of the meeting will be post entries.

No entry fee will be refunded unless the competitor is prevented by sickness from appearing on the range, and then only on order of the executive officer.

Team captains can expedite matters by securing from the statistical officer blank forms of entry in advance, and having them filled out with the names of the team, which should be written plainly and in full, with military rank, if any.

Entry tickets for individual matches will not be exchanged for entry tickets in other matches.

All entries not otherwise provided for in the program must be made not later than thirty minutes before the hour for calling the match.

All civilians, as well as members of the organized militia, Army, Navy, Marine Corps, Cadets United States Military Academy, and Midshipmen United States Naval Academy are eligible to compete in all the individual matches that are open to everybody, provided they shoot with the arm called for in the conditions of the match.

14. TIES.—Ties will be decided as follows:

(*a*) In individual shooting, at known distances—

(1) When the firing takes place at more than one distance, by the total score made at the longest distance, and if still a tie, and there be three or more distances in the competition, by the total score at the second distance, and so on for each of the successive distances.

(2) By the fewest misses in the entire score.
(3) By the fewest outers in the entire score.
(4) By the fewest inners in the entire score.
(5) If still a tie, by inverse order of shots, counting singly from the last to the first.
(6) By firing single shots at the longest distance.
(7) In case a tie is of the highest possible score, those tying will shoot the tie off at the close of the meet or they may divide the prize or prizes instead.
(8) In case the winner of the match is to be decided by the total of two or more tickets and there is a tie in totals, the contestant having the single ticket of the highest value shall rank first.

(*b*) In team shooting at known distances—
(1) By the aggregate of the total scores made at the different distances in inverse order.
(2) By the fewest misses in the entire score.
(3) By the fewest outers in the entire score.
(4) By the fewest inners in the entire score.
(5) By the totals, for the team, of the final shot of each competitor.
(6) By the totals, for the team, of these successive closing shots in inverse order.

When the ties are to be divided, it must be so stated in the conditions of the match; but the winners may by mutual consent divide the prizes.

Ties, when rapid fire is included in the match, will be decided as follows:

(*a*) In slow and rapid fire—
(1) By the highest total score made in rapid fire; if still a tie, by the highest score made in rapid fire at 500 yards; if still a tie, by the highest score in rapid fire at 300 yards; if still a tie by the highest score in rapid fire at 200 yards. In the same manner the decision will be regulated by the highest total scores in succession made at 600, 500, 300, and 200 yards, slow fire.
(2) By the fewest misses in rapid fire.
(3) By the greatest number of hits on figure in rapid fire.
(4) By the fewest misses in slow fire.
(5) By the fewest outers in slow fire.
(6) By the fewest inners in slow fire.
(7) If still a tie, by firing single shots at he longest range, slow fire.

(*b*) In skirmish fire—
(1) By the greatest number of penalties imposed.
(2) By the greatest number of hits.
(3) By the fewest hits in kneeling figures.
(4) If still a tie, a special run in skirmish fire.

Ties, when rapid and skirmish fires are included in the aggregate score, will be decided by giving precedence to the competitor having the best total

score in the skirmish fire. If the scores in the skirmish fire are also of the same total, the order of merit for that fire (and therefore the final order of merit) will be determined in accordance with paragraph "Ties, when rapid fire is included in the match," etc.

In pistol competition (in the aggregate score).—Upon the completion of a pistol competition, ties found in the aggregate scores of two or more competitors will be decided as follows:

(1) By the highest aggregate score made in rapid fire; if still a tie, by the highest total score made at 25 yards, rapid fire. The tie continuing, it will then be regulated, in succession, by the fewest misses and by the greatest number of hits on the figure, both in rapid fire.

(2) If necessary, the comparison will then extend to timed fire, and will be decided in the following order:

(*a*) By the greatest number of penalties imposed.
(*b*) By the highest total aggregate score.
(*c*) By the highest total score made at 50 yards.
(*d*) By the fewest misses at both ranges together.
(*e*) By the fewest outers at both ranges together.
(*f*) By the fewest inners at both ranges together.

(3) The tie still continuing, the comparison will then extend to slow fire and will be decided in the following order:

(*a*) By the highest total score made at 75 yards.
(*b*) By the fewest misses at both ranges together.
(*c*) By the fewest outers at both ranges together.
(*d*) By the fewest inners at both ranges together.

(4) If there be still a tie, it will be decided by firing single shots at 75 yards, slow fire.

15. HOURS OF FIRING.—Assembly will be sounded and firing begun at 8 o'clock a. m. and "Cease firing" will be sounded at 6 p. m. unless otherwise ordered by the executive officer.

The range will be closed for an hour in the middle of the day for lunch.

16. GENERAL.—Prizes not claimed within thirty days after having been won shall be forfeited to the Association.

These regulations and such special rules or directions as the executive officer may give must be rigidly complied with by competitors and all other persons upon the range grounds.

Competitors and all others connected with the competitions must make themselves acquainted with the foregoing regulations as well as with the conditions of competitive firing in which they may be participating, as the plea of ignorance of either of them will not be entertained.

[1101618—M. S. O.]

BY ORDER OF THE SECRETARY OF WAR:

J. C. BATES,
Lieutenant General, Chief of Staff.

OFFICIAL:
F. C. AINSWORTH,
The Military Secretary.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE OLD FRENCH BRONZE GUNS AT THE VIRGINIA MILITARY INSTITUTE, LEXINGTON, VA., AND AT THE U. S. NAVAL ACADEMY.

By LIEUTENANT-COMMANDER E. L. BEACH, U. S. Navy.

There are a great many old bronze guns at the Naval Academy; eight of these are heavy 24-pounders, and six of these eight have French inscriptions, and are of French manufacture; the other two 24-pounders have Spanish inscriptions; this paper discusses only the six 24-pounders of French origin, the history of the many other bronze guns being fairly well known.

It has always been said that all of these heavy bronze guns were captured by our warships during the Mexican war; recently all of the trophy guns at the Naval Academy were catalogued, and it proved a great surprise to the cataloguer and to most officers at the Naval Academy that six of these guns were undoubtedly of French origin. A futile attempt was made to trace the history of these guns; the records of the superintendent's office were carefully examined, the archives of the Navy Department were searched, the library of the latter was explored, and also the library at Annapolis; nothing whatever was found that showed how these guns came to the Naval Academy.

A great many of the lighter bronze guns are inscribed, "Taken by the Navy in California in 1847." But none of these heavy 24-pounders are so marked, nor are all of the smaller pieces.

The history of these guns then became interesting; it seemed strange that French guns should have been captured in Mexico during the Mexican War.

All of these French guns bear the motto, "Ultima Ratio Regum"; in Belton's "Literary Manual of Foreign Quotations" the following is found, under the quotation "Ultima Ratio":

"The words Ultima Ratio Regum were frequently engraved

on the cannon of the old French monarchy, and they may be seen on the pieces of artillery presented to the colonies by Louis XVI. Some of these are now in the yard of the Naval Academy at Annapolis, and two of them are in front of the War Department Building in Washington."

This seemed a reasonable clue, and hundreds of volumes that bore upon the relation between France and the United States during our Revolutionary War, were searched, and the official correspondence was read, and not one item was found that could be considered as directly bearing upon these guns.

References were found to the effect that La Fayette had brought over arms and ammunition, that the French Government sent over the same, and that Virginia, in her own name, bought military stores and *heavy artillery* in France in 1778, and thereabouts.

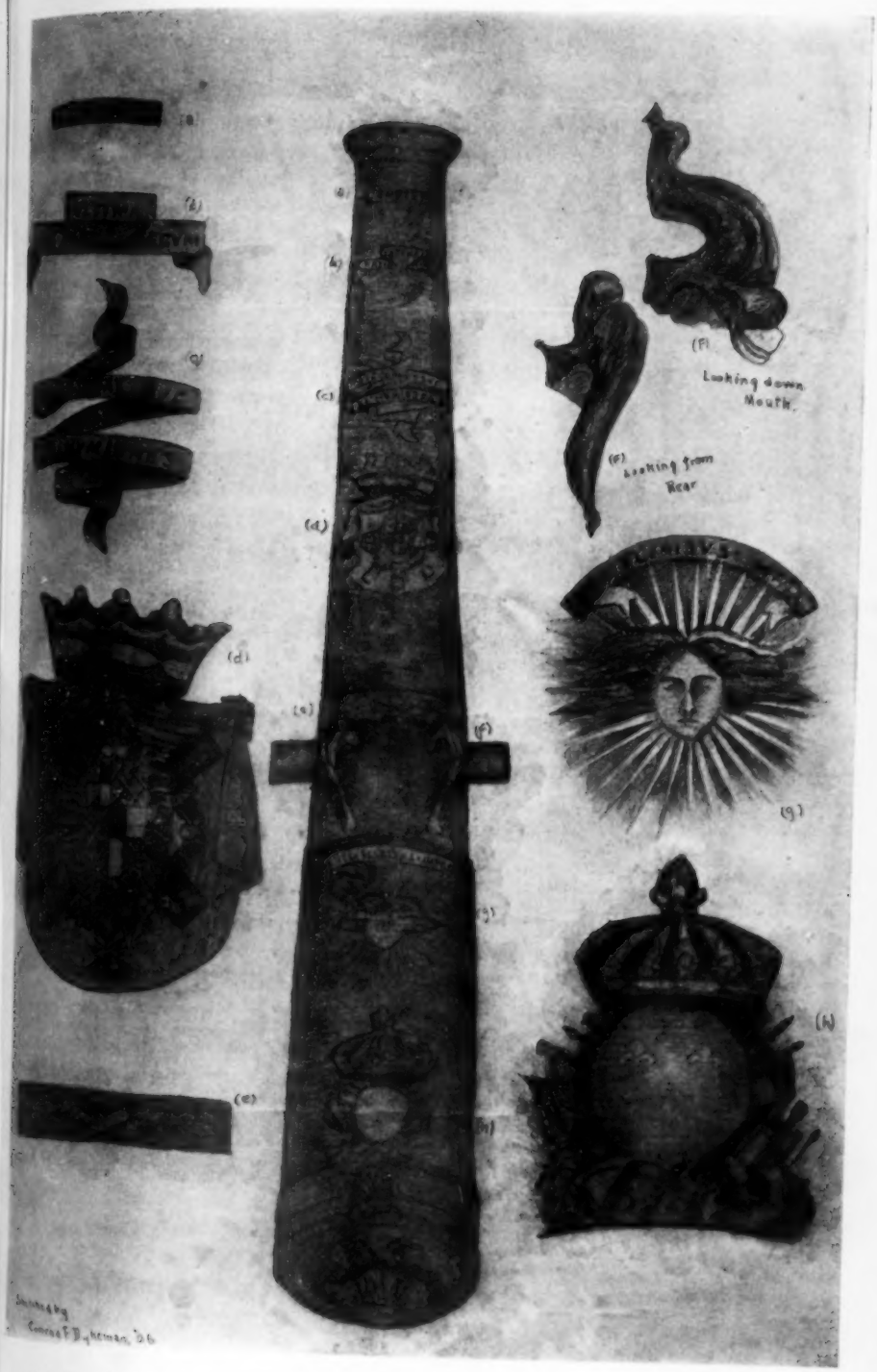
In General Winfield Scott's official report, after the capture of Vera Cruz, he states that he was going to send to the United States eleven or twelve very fine bronze guns taken from the castle of San Juan de Ulloa. In his "Recollections of a Naval Officer," W. H. Parker, in describing the capture of this castle, at which he participated, speaks of sending some of the beautiful bronze guns taken from the castle to the United States, and says that some of these were sent to the Naval Academy. In Professor Soley's History of the Naval Academy is an item to the effect that there are eight long brass guns at the Naval Academy, "originally French," taken by our naval ships from the Castle of San Juan de Ulloa, Vera Cruz, in 1847.

In reality, only six of these eight long bronze guns were "originally French"; two of them have Spanish inscriptions, and were cast, according to these inscriptions, in Seville, in 1732, and 1747, respectively.

Enough has been said to show that the history of these six bronze 24-pounder French guns is, for the present at least, shrouded in mystery.

In my efforts to ascertain some knowledge concerning the origin of these guns I was brought into correspondence with General T. T. Munford, formerly of the Confederate States army, now of Lynchburg, Va.; to my surprise I learned from him that the exact counterpart of our Naval Academy French guns were to be found on the grounds of the Virginia Military Institute, at

NO. I.



NO. I. L'ENVIE. AT VIRGINIA MILITARY INSTITUTE, LEXINGTON, VA.

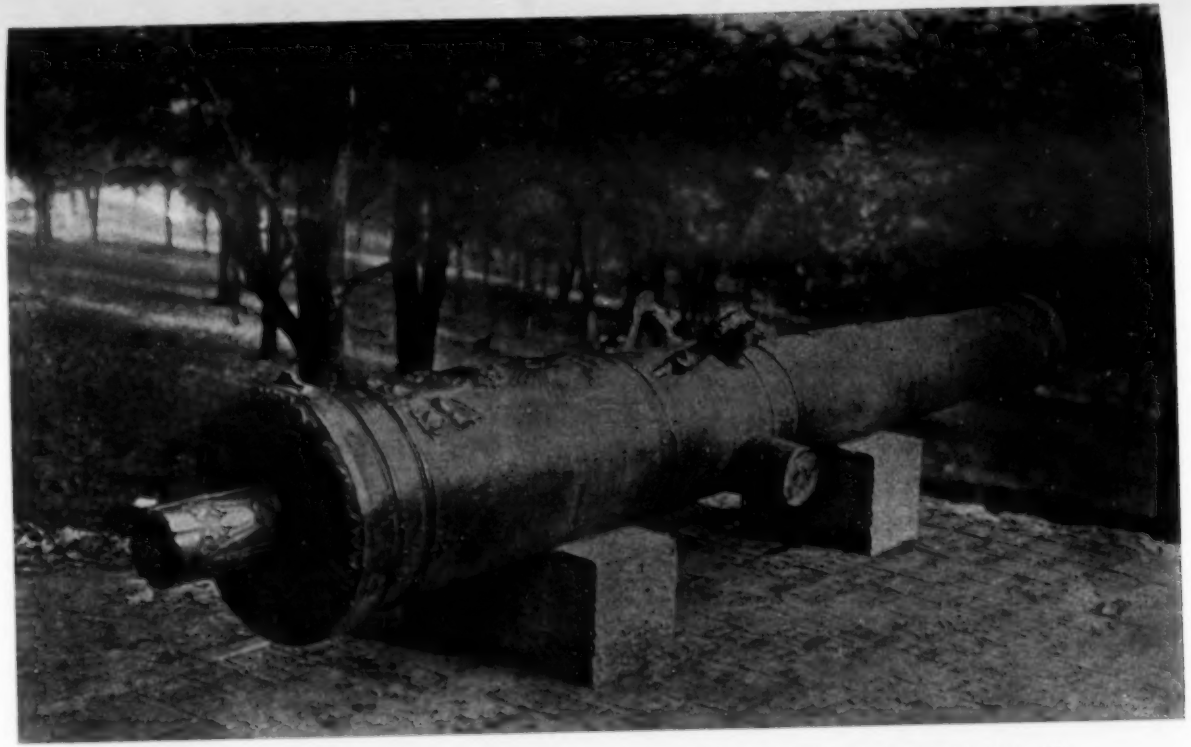
Lexington, Va., and had been in Virginia since Revolutionary days. General Munford sent me photographs of the Virginia guns, which differ in no respects whatever from our Naval Academy guns, and it is difficult to conceive that they should have had a different history in arriving in this country; gradually the knowledge of other French bronze guns came to hand. At present the existence of twelve of these large 24-pounders is known to the writer; two are at Lexington, two at West Point, two in Washington, and six are at Annapolis; these are nearly 12 feet long and average 5500 pounds in weight; it has also been learned that there are many smaller French bronze guns at different places; some are at West Point, over 50 are at the army arsenal at Watervliet, New York, and there are many in other arsenals. Almost every Congress presents a bronze gun or two from one of its arsenals to some city upon request. And much correspondence on my part has not developed anything beyond speculation as to the origin of any.

An attempt will be made to describe these Virginia, and also the Annapolis 24-pounders.

A drawing and a number of photographs accompany this paper, which will give some idea of the beautiful ornamentation of these guns.

The first is from a drawing made by Mr. Conrad F. Dykeman, of the class of '06, Virginia Military Institute, for General Munford, of one of the two remaining Lexington 24-pounders. The second is from a photograph of the same gun. The same beautiful carvings are found on the exterior of all of these 24-pounders, wherever they may be; these inscriptions and carvings are specimens of the most exquisite workmanship; each gun has its own name, and the name of some member of the Bourbon family of France; the mottoes, "Ultima Ratio Regum," and "Nec Pluribus Impar"; each gun has ornate scroll work, carvings of a woman's head, Bourbon coats of arms, crowns, fleur-de-lis, drums, cannons, flags, shields, etc.; each gun has its date and place of manufacture. The dates run between 1678 and 1756; there are slight differences between the carvings of the breech according to the date of the gun.

The drawing and first photograph is of the Lexington gun, which bears the name "L'Envie." It was cast in Duaci in 1693. The second Lexington gun is a counterpart of "L'Envie." It was cast in Duaci in 1678.



NO. II. L'ENVIE. 1678. AT VIRGINIA MILITARY INSTITUTE, LEXINGTON, VA.

Illustration No. III is of the oldest of the Annapolis guns. The name of this gun is "Le Mordicant." It was cast in Duaci in 1685. The first three illustrations are correct for anyone of these three guns, for either of those at Lexington, or for the oldest of the Annapolis guns.

There are five other Annapolis guns, as follows: "Le Grandeur," 1756; "Le Fier," 1755; "Le Robuste," 1755; "Mars,"

NO. III. LE MORDICANT. 1685. AT ANNAPOLIS, MD.

1755; "Le Gaillard," 1748. There are slight differences between the first three older guns, and the last five; the three older guns have the inscription, "Le Mareschal Duc de Humieres." In the place of this on the guns of more recent date is found "Louis Charles de Bourbon, Comte d'Eu, Duc D'Aumale." On the rim of the breech of the older guns are the words, "Kelleri Tiguri Helvitii," which are not found on the five newer guns at Annapolis.

Illustration No. IV is of "Mars," 1755.

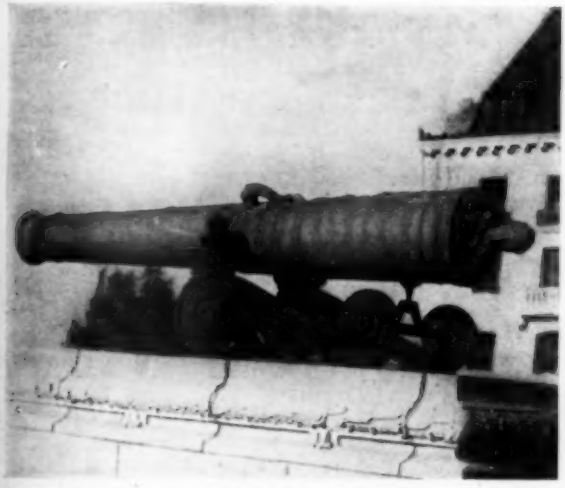
Illustration No. V is of "Le Fier," 1755.

Illustration No. VI is of the breech of one of the five newer guns.

Illustration No. VII is of one of the two 24-pounder guns in front of the War Department Building, at Washington.

Illustration No. VIII is of a Spanish 24-pounder, which was probably taken from the Castle of San Juan de Ulloa.

Illustration No. IX is of a number of Spanish 12- and 18-pounders, taken by the navy in California in 1847.



NO. IV. MARS. 1755. AT ANNAPOLIS, MD.

The greatest difference between the three older and five newer guns is in the breech. In the older guns it is a wreath of leaves; in the newer guns the breech is carved into semblance of a horrible face belching forth the cascabel.

Of the Annapolis guns I have been able to find no record whatever of their history; Belton says they were presented to the American colonies by Louis XVI. Soley says they were captured at Vera Cruz. W. H. Parker says that at Annapolis are to be seen guns captured at Vera Cruz. General Scott reported sending home from Vera Cruz 11 or 12 bronze guns. Their history is open to speculation.

But with the Virginia guns there is a complete record since the ending of the Revolutionary War. Facts relating to them are found in different places in the Virginia state papers, and I am indebted to General Munford for furnishing me with these facts, and for copies of different items.

It is evident from the transactions recorded in the Virginia

NO. V. LE FIER. 1755. AT ANNAPOLIS, MD.

state papers that in the early days of this republic Virginia acted as a sovereign state; amongst other things, on March 18, 1778, she commissioned a Frenchman, Colonel Le Marie, to go to France and purchase military stores and arms, not for the colonies, but for Virginia; it is recorded that he returned to Virginia with military stores and heavy artillery; but more detailed knowledge of what this artillery was is not recorded.

The following is from the Virginia State Papers. (From Col. William Davies to the governor of Virginia.)

WAR OFFICE, March 31, 1781.

Sir: Captain Young, the quartermaster-general of the state, who has just arrived, informs me that he saw at Edenton about 30 exceeding fine cannon of 18's and 24's. He asked the naval officer whose they were, who informed him they were the property of the state of Virginia, thrown out of a French vessel, who carried the remainder of them to South Quay. As I have no return of anything of the kind I would be glad to be informed whether your excellency has any account of such cannon. . . . .

(Endorsed by the Governor), March 31.

The cannon at Edenton are not the property of this state but of No. Carolina, which purchased a part of the same cargo, of which the residue was purchased by us.

(Signed) TH. JEFFERSON.

NO. VI. BREECH OF THE MORE RECENT GUNS, AT ANNAPOLIS, MD.

In 1781 La Fayette was operating in Virginia against Cornwallis. In a retreat towards Richmond his rear guard was overtaken by Tarleton at Hanover Court House; in his report of this action to Sir Henry Clinton, Tarleton says: "Near Hanover Court House we found ten French bronze cannon, 24-pounders, too heavy to move or to destroy, except to spike, and to throw five or six into the Pamunkey River." Here is another letter from Col. Davies to the governor of Virginia, dated Feb. 25, 1782.

The cannon in the Pamunkey River were those I had brought up from York and Cumberland, and were taken by the enemy at Taylor's Ferry (Hanover Court House), and thrown into the river.

In May, 1793, a bill was rendered against the State of Virginia by Thomas Newton, Jr., for hauling large cannon out of the Pamunkey River. In the same year it is recorded that John Taylor paid the State of Virginia 75£ 6. 8. for one of the cannon lying at Taylor's Ferry. In these Virginia State Papers are many indefinite casual references to bronze guns, lying in different places in Virginia; at one place there is an item that states that many of these guns were taken to Portsmouth, Va., to arm different U. S. frigates.

On January 5, 1802, John Newell was paid by the Commonwealth of Virginia 78£ 12. for hauling nine cannon from Taylor's Ferry to Richmond. These nine, with the one sold to John Taylor, account for the ten guns spiked by Tarleton.

In 1808 Virginia exchanged three of these nine guns with the United States government for smaller field pieces, and during the Civil War four of the remaining six were cast into lighter guns, which became famous before the close of that war as the Letcher Battery. Lieutenant Charles Ellis Munford, a brother of General Munford, was killed at Malvern Hill while in command of these guns.

In a letter dated at Richmond, June 8, 1804, from John Clark, Superintendent of the Public Armory, he speaks of guns "lying about the country in the same neglected state as they were left at the end of the revolution, some buried in the earth and others in the rivers." This is good evidence that even after the nine guns had been hauled to Richmond, in 1802, there were still many other guns in Virginia, not now accounted for.

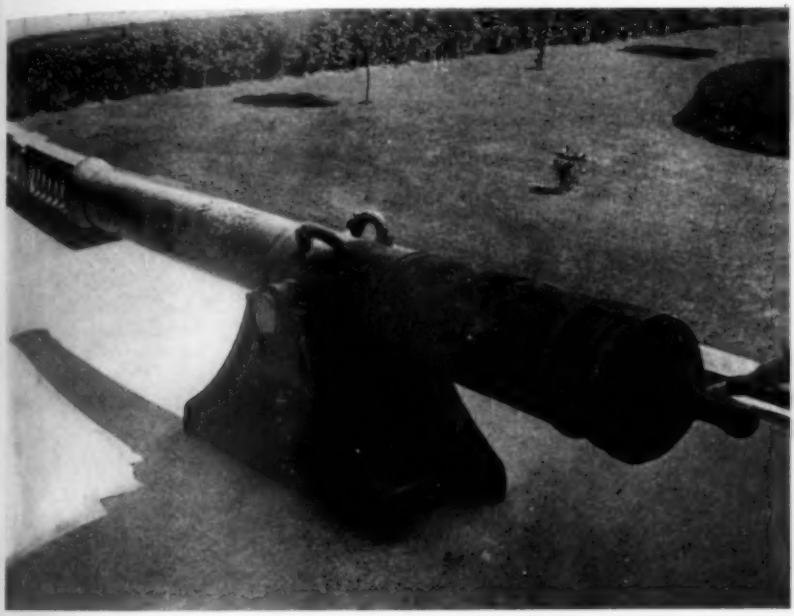
In 1816 a sloop commanded by a Captain Chase recovered from the York river a French bronze cannon, named "La Divertissant," cast in 1686. The governor of Virginia claimed this as property of the State; Captain Chase refused to give it up, and the governor brought suit to get possession of it. This was tried before Chancellor Taylor, in January, 1817, who decided against the governor, ruling that it was "not proved to the satisfaction of the court that the said cannon was ever the property of the Commonwealth of Virginia."

I have given but an incomplete bird's-eye view of the history of the Lexington guns from the records so kindly furnished me by General Munford, but enough to prove that Virginia bought heavy artillery from France, during the Revolutionary War; that

there were French bronze guns captured from the Americans by Tarleton, that later nine of these guns, 24-pounders, were hauled to Richmond, and that the two guns now at Lexington were two of the ten guns spiked by Tarleton.

But were these ten guns the "heavy artillery" purchased by Virginia from France during the Revolutionary War?

General Munford believes they were; but I cannot bring myself to his views on this point.

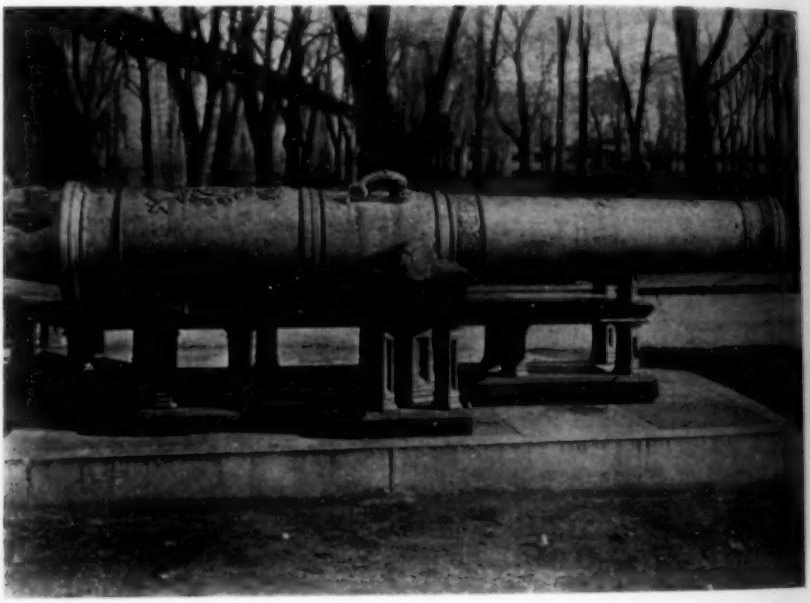


NO. VII. IN FRONT OF WAR DEPARTMENT, WASHINGTON, D. C.

First, it is not conceivable that Virginia should have wanted such heavy guns for her purposes. Such guns could never have been part of the artillery of a moving army. Also, these ten guns were but a small part of the number of French bronze guns known to have been in Virginia at the close of the Revolutionary War; it would seem that if Virginia had bought these guns there could not have been the confusion as to the ownership of them as is evinced by the letter already quoted from Col. Davies, a state military official, to the governor of the state, which letter was written less than three years after the receipt of the "heavy

artillery." Furthermore, in 1817, while Jefferson and many Virginians who had been prominent in Revolutionary days were still living, a judge of Virginia decided that there was no evidence to prove that Virginia ever had owned a particular bronze gun, a counterpart to the guns now at Lexington.

And still further, there are many similar guns, in United States arsenals, Annapolis, and elsewhere, so exactly similar that one feels that they must all have had a common history in their arrival in this country.



NO. VIII. EL MENALEAS. 1732. SPANISH 24-POUNDER. PROBABLY FROM THE CASTLE OF SAN JUAN DE ULLOA, VERA CRUZ. MEXICAN WAR. AT ANNAPOLIS, MD.

And when was this arrival?

This can be but a matter of conjecture, but there are several significant facts. One is that it is evident that there were hundreds of these old French bronze guns in this country at the end of the Revolutionary War, and there are a great many still remaining, though I know of but 12 of the larger size, 24-pounders.

Another significant fact is that the most recent date on any of them is 1756.

A most significant fact is that when Stony Point was captured from the British by General Anthony Wayne, in 1779, it was defended by a number of these old French bronze guns. These are now at West Point.

Where did all of these old French guns come from?

I offer the following as my opinion: it was suggested to me by Miss Mary Louise Dodd, of Covington, Kentucky.

During the old French and Indian war, 545 guns were taken from the French frigates captured or burned at Lewisburg, and many hundreds from the fort; likewise thousands in all of French

NO. IX. SPANISH 12 AND 18-POUNDERS TAKEN IN CALIFORNIA BY NAVY IN 1847. AT ANNAPOLIS, MD.

guns were taken at Quebec, Montreal, Crown Point, Frontenac, and other French-Canadian military strongholds; these were captured by the British soldiers and sailors and American colonial troops. At the beginning of the Revolutionary War among the first acts of the American troops was the seizure of arsenals where thousands of cannon were stored; this was the artillery used by our troops; what were these cannon? What became of them?

I believe the old French guns left in Virginia at the close of

the Revolutionary War were among those captured from the French in Canada during the last colonial war; attention is again referred to the fact that the most recent date of any of the French guns is 1756, the date of the beginning of that war.

I have to offer my belief concerning the Annapolis guns, as follows:

William H. Parker, in his "Recollections of a Naval Officer," states he was one of the first officers ordered to the Naval Academy when it was founded by George Bancroft, in 1846. He speaks of Fort Severn, then an army post, being transferred to the navy; in commenting upon this fort he says it was defended by a number of bronze 24-pounder guns. In another place he speaks of there being six 32-pounder bronze guns at the fort. I have noticed that these guns, which are really 24-pounders, are frequently spoken of as 32-pounders.

It is my opinion that when Fort Severn was built in 1808, it was armed with six old French 24-pounders, which had originally been captured in the old French and Indian war. That when Fort Severn was given to the Navy Department, the six 24-pounder guns went with the fort, and that these are the six guns we still have with us.

The drawing and photograph of the Lexington guns, and the photograph of the War Department gun were lent to me by General Munford. The photographs of the Annapolis guns were taken by Midshipman Follett Bradley.

TROPHY GUNS AT U. S. NAVAL ACADEMY.

Catalogued by E. L. BEACH, U. S. Navy.

OLD FRENCH GUNS. 24-PDRS. 12 FEET LONG.

1. Le Mordicant. Inscriptions: Ultima Ratio Regum; Le Mareschal Duc de Humieres; Nec Pluribus Impar; Kelleri Tiguri Helvetii F. Duacio, 1685.

   Beautiful carvings of crowns, shields, lions, dolphins, woman's face with radiating arrows, fleur de lis, flags, drums, cannon, etc. The breech is carved into shape of beautiful wreath of leaves.

2. Le Grandeur. Inscriptions: Ultima Ratio Regum; Nec Pluribus Impar; A Douay. Par J. Berenger, Commissaire des forts le 12 Juin, 1756.

   Beautiful carvings of crowns, woman's face, fleur de lis, dolphins, drums, shields, cannon, flags, scroll work, etc.

3. Le Fier. Inscriptions: Ultima Ratio Regum; Louis Charles de Bourbon, Comte d'Eu, Duc d'Aumale; Nec Pluribus Impar; A Douay par J. Berenger, Commissaire des forts, 1755.

Beautiful carvings of dolphins, woman's face, crowns, fleur de lis, flags, drums, shields, etc. The breech is carved into semblance of a horrible face, belching out the cascabel, or *boutin*.

4. Le Robuste. 6 Febre, 1755. Inscriptions and carvings same as No. 3.

5. Le Gaillard. 1748. Inscriptions and carvings same as No. 3.

6. Mars. 1755. Inscriptions and carvings same as No. 3.

GUNS CAPTURED BY AMERICAN NAVAL VESSELS FROM THE BRITISH IN WAR OF 1812.

1. 24-pdr. Captured from British flagship *Confiance* on Lake Champlain, September 11, 1814, by Commodore McDonough, U. S. Navy. This gun is indented by marks of shot on left side, from breech. This is the gun, which, by its recoil, killed Commodore Downie, the British commander.

2. 24-pdr. From British ship *Confiance*, mate to, and captured at same time as No. 1.

3. 12-pdr. Taken from the British ship *Macedonian* after her surrender to the American ship *United States*, Captain Decatur, commanding, on October 25, 1812.

4. Mate to, and same history as No. 3.

5. Mate to, and same history as No. 3.

6. Mate to, and same history as No. 3.

7. 32-pdr. Carronade. Captured with British ship *Cyane* by Captain Stewart, commanding *U. S. S. Constitution*, War 1812.

8. 32-pdr. Carronade. Mate to, and same history as No. 7.

9. Treadway 32-pdr. Carronade. Probably used aboard American war ship in War of 1812.

MEXICAN WAR GUNS TAKEN BY SHIPS OF THE AMERICAN NAVY FROM THE MEXICANS IN CALIFORNIA IN 1847.

1. Bronze. 12-pdr. Mark on Muzzle, "Taken by the Navy in California in 1847. Inscriptions: "El Neptune"; Violati Fulmina Regis; En Manila año de 1781; Gouerno estas islas Philips Elm y sdiph Basco y Bargas; Carolus Tercius Hispaniarum et Indiarum Rex.

2. Bronze. With old but clear inscriptions of names, crowns, coats of arms, año 1673. About 12-pdr.

3. Similar to No. 2. Near muzzle in heavy letters is the name "Andres Melendez." Name of gun "Jesus," año 1675. About 12-pdr.

4. Similar in all respects to No. 1. Cast in Manila in 1781. Name "El Faetonte." Same carvings and inscriptions as No. 1.

5. 8-pdr. Bronze. "El Dromedario" 1766.

6. 12-pdr. Bronze. "San Telesforo" 1793.

7. Old Spanish gun, with beautiful castings and carvings. Inscriptions deep lettered. "San Cayetavo" "1686." About 18-pdr.
8. Old Spanish gun. Bronze. About 18-pdr. Inscription similar to No. 3. "1686." See illustration No. IX.
9. Old Spanish gun. Bronze. About 18-pdr. Similar to No. 3. "1687."
10. Bronze. 12-pdr. Spanish gun. Beautifully carved with crowns, scroll work, coats of arms, etc. Inscriptions as follows (deep letters): "Reynnando El SDCN Tercero; Siendo Virrey Governador y Capitan General el Exms D. Manuel de Armat y Jument; Sefondieron en Lima; Año de 1767; Por Pablo Tovn y Hver.
11. Bronze. 8-pdr. "El Gaillard." "1756."

MEXICAN WAR GUNS TAKEN BY NAVY FROM CASTLE OF SAN JUAN DE ULLOA, WHICH SURRENDERED MARCH 27, 1847.

1. Small mortar, eprouvette.
2. Bronze, long (12 feet), heavy, 32 pdr. Spanish gun, with beautiful carvings of coats of arms, scroll work, crowns, etc. Inscriptions: "El Barazeto; Violati Fulmina Regis; Fernandez VI D. G.; Hispan et Ind. Rex; Solano Fecit Sevilla año de 1747.
3. Similar to No. 2. Bronze. Fleur de lis carved on upper side. Inscriptions: El Menaleas; Violati Fulmina Regis; Philip V. Hispaniar Rex; Isabefarne Hisp. Regin; Solano Fecit Sevilla año de 1732. See illustration No. VIII.
4. Bronze. 8-pdr. Cast in Barcelona, 1767.
5. Bronze. Similar to No. 4.
6. Bronze. Similar to No. 4.

CAPTURED CONFEDERATE GUNS OF CIVIL WAR.

1. 8-inch Armstrong-Shunt rifle. Captured from the Confederates at Fort Fisher, 1865.
2. 100-lb Brooks rifle. Mounted first on board the Confederate Ram *Albemarle*, in 1864. Captured from the Confederates at Morris Island, S. C.
3. 80-lb. Whitworth rifle. Captured from the Confederates at Morris Island.
4. 5-inch Blakely rifle. Captured from the Confederates at Fort Fisher, 1865.
5. 60-lb. M. L. R. Manufactured at Galveston for the Confederate government from the shaft of the *U. S. S. Westfield.*
6. 30-lb. M. L. R. Manufactured at Galveston for the Confederate government from the shaft of the *U. S. S. Westfield.*

FEDERAL GUNS OF CIVIL WAR.

1. 30-lb. Dahlgreen rifle. Strapped. History unknown.
2. 30-lb. Dahlgreen rifle. History unknown. Said to have been first gun cast in Civil War.

SPANISH WAR TROPHY GUNS.

1. 14-cm. R. F. gun from *Maria Teresa*. Length, 17 feet 6 inches. "Arsenal de Caracas, 1897."
2. 14-cm. R. F. gun from *Viscaya*. Length, 17 feet 6 inches. Marked "Artilleres de l'Nervion, Bilboa, 1893.
3. 5½-inch smooth bore. Bronze. Length, 9 feet 6 inches. From Cay Toro, Guantanino Bay. Sevilla 20 de Junio, 1805.
4. 3¼-inch Krupp B. L. R. Steel. From wreck of Spanish cruiser *Don Jorge Juan*, at Nipe Bay. Action of July 21, 1898.
5. 3½-inch muzzle loading bronze field piece, on carriage. Philippine trophy.
6. 37-mm. Hotchkiss revolver cannon. From *Reina Mercedes*.
7. 37-mm. H. R. C. (same as No. 6), from *Reina Mercedes*.
8. 2 boat guns, 1-pdr. B. L. R. From the *Viscaya*. Marked "Arsenal de la Carraca, 1890 and 1893."
9. 2 boat guns. Make, Schneider. 7-cm. Captured at Sangley Point, near Manila, by Admiral Dewey, May 1, 1898.
10. 2 short 1-pdr. Hotchkiss boat guns. From *Reina Mercedes*.
11. Mortar. Bronze. Smooth bore, 14¾-inch. From Manila. Marks Cobres de Mexico y Peru. Sevilla, 1779.
12. Mortar, 12¾-inch, smooth bore. Bronze. From Manila. Marks Cobres Yanges y Mexico. Sevilla, 1784.
13. Mortar, 9½-inch. Bronze. Smooth Bore. From Manila. Marks El Insolente, Barcelona, 1769.
14. 3½-inch rifled muzzle loading field gun. Bronze. Taken from Filipino insurgents at Balbee, P. I., by *U. S. S. Manila*. Cast in Seville, 1801.
15. Barrel Nordenfelt gun, (11-mm), from one of the vessels destroyed by Admiral Dewey, May 1, 1898.
16. Old Spanish gun, mounted by Filipinos, and fired by them from Old Cavite, into the U. S. Navy Yard at Cavite, on June 13, 1899. Cast in Barcelona in 1803. Remodeled into a Krupp B. L.

GUNS, MISCELLANEOUS.

1. 12-inch wrought iron gun, called Oregon. Designed by Commodore Stockton, U. S. Navy. The mate of this gun, called "The Peacemaker," was mounted on board the *U. S. S. Princeton*, and exploded on being fired, killing the secretary of the Navy and a number of other officials.
2. Italian 6-inch rifle, presented to the United States by the Italian government.
3. 2 brass guns, 12-pdr. Made for the army for use in the Mexican War. Cast in 1846.
4. 2 brass signal guns on wooden carriages. From the yacht America.
5. 2 brass signal guns on iron carriages, said to have been from Confederate privateer *Shenandoah*.

6. Old brass signal gun, Spanish make. Said to have been from an old privateer. History unknown.
7. Corean gun. Cast in 1313. Breech loading.
8. Corean gun. Cast in 1655. Breech loading.
9. Corean gun. Cast in 1680. Breech loading.

The above Corean guns were captured in the action between American sailors and marines under the command of Rear-Admiral John Rodgers, U. S. Navy, and Coreans, in the attack on the Corean forts. They have inscriptions giving their history; these have been translated. For a complete description of these guns see Naval Institute Proceedings, No. 62, Vol. XVIII.

10. The Cortez gun. Bronze. Breech loading. Cast in Spain in 1474. Brought to Mexico by Cortez, and used by him in the conquest of Mexico.
11. International gun. An old 6-pdr. muzzle loading gun used against the Boxers, from the legations, in Pekin, in 1900. This gun was fitted for use by American marines, and used with telling effect against the Boxers.
12 Four small makeshift Filipino guns, of rude manufacture. One of wood, covered by caraboa hide. Three of iron, covered by wood. Used by Filipinos against Spaniards. Presented to Admiral Dewey by the Archbishop of Manila.
13. Small wooden gun known as "batamka," used by Filipinos, and captured from them by Americans in Island of Samar, Philippine Islands.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

GUN DISTRIBUTION ABOARD MODERN BATTLESHIPS, AND ITS INFLUENCE ON NAVAL TACTICS.

Translated by LIEUTENANT-COMMANDER H. F. BRYAN, U. S. N., from the *Mitteilungen aus dem Gebiete des Seewesens.* With comments by PROFESSOR P. R. ALGER, U. S. N., and COMMANDER B. A. FISKE, U. S. N.

The means of attack and defense of a battleship are: the gun, the torpedo, and the ram; the last two, of course, are only occasional weapons; a special importance must not be denied to the ship's engines, for only engines of high power can assure an effectual use of the weapons. If the conning tower represents the brains of the ship, the engines may with equal justice be called its heart.

The chief weapon of the battleship was, and still is, the gun, at present the heavy 30.5-cm. gun—the more of these guns a battleship has, the better.

The leading aim in battleship construction is to obtain the maximum effective fire of the entire battery on the broadside. Tactically this effort may be thus expressed: The enemy will be kept abeam when possible, to obtain the best use of this battery.

Within the broadside arc of train of 90° (eight points), 45° forward and 45° abaft the beam, the maximum number of guns can be brought to bear; this fact influences every tactical maneuver. If either of these extreme bearings be passed during an engagement a part of the battery must cease firing, which is naturally equivalent to lessening one's own fire.

Keeping the enemy abeam is, however, not only the best offensive, but also the best defensive position. The longitudinal and vertical errors of guns are much greater than the lateral errors; a ship with the enemy on the bow offers a target of

greater height than on the broadside on account of the conning tower, bridges and other upper works.

In this position, as the middle of the target presented will generally be aimed at, the longitudinal and vertical dispersion will have a larger area for accidental hits, for shots will hit that would otherwise pass over the ship. The conning tower, in this case, becomes a "catch all." With the broadside turned to the enemy, this height and the depth in range of the target presented is less than with the enemy on the bow; and therefore chance hits due to longitudinal and vertical dispersion will be reduced to a minimum. In broadside fighting, not only can the greatest possible number of guns be brought to bear, but the probability of chance hits is lessened.

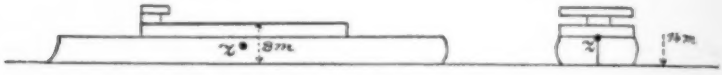


FIG. 1.

[*While it is true that under some conditions a ship bows-on offers a better target than when broadside on, it is thought that the author greatly exaggerates the disadvantages of the latter position. The bow presentation offers a higher but narrower target than the broadside presentation, and from that point of view is easier or harder to hit according to the relative values of the vertical and lateral mean errors of the gun, the relation between which errors varies with the range. When firing at a directly approaching ship the lateral errors of gun fire should be small, but, on the other hand, the range is changing most rapidly. Bows-on, the hits are much more likely to be glancing, and moreover a waterline hole near the bow is less important than one on the broadside. The conning tower, forward turret and fire control station as a group are the natural point of aim, and offer the same target whatever the presentation of the ship. This refers to gun-fire only; the broadside offers an enormously better target for torpedoes than the bow.*]

The same thing holds true for several ships maneuvering in formation. The best battle formation is therefore the simple exact column; mass formations are fundamentally bad, because a compact mass is favorable to wild shooting by the enemy; and,

besides, it would result in a reduction of one's own fire, on account of the unavoidable masking of the fire of some of one's own ships while executing evolutions.

As victory is not won merely by shooting, but by hitting, it is essential to so maneuver as to avoid frequent changes of target—after the range has once been obtained.

This can most readily be done by taking up a position abreast the enemy, at a favorable range, on a parallel or nearly parallel course.

A restless conduct of a battle, caused by constant turns, or by the execution of maneuvers, which require large changes of course, makes it necessary to find the range anew, after every change; and thus prevents the attainment of what is wanted—a continuous and intense fire.

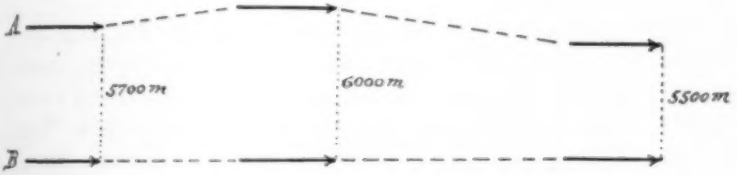


FIG. 2.

[*Changes of range embarrass both sides equally, but changes of bearing caused by turning are detrimental only to the side turning.*]

One's own fleet can always change the range by small changes of course not evident to the enemy, for example, one point at a time. These movements should be made without signals; the leader of the column turns gradually toward or away from the enemy; and the other ships follow in his wake.

As the change of distance is accurately known to the one making it, he can renew the engagement sooner than the enemy; he must merely to avoid "cease firing" carry out changes of course very gradually; the fire control stations, the battery or other gun commands will be informed of the desired changes of range at the proper time by a message "Range is increasing" or, "Range is decreasing." It is therefore evident that if *A* (Fig. 2) is not to drop behind *B* in a broadside fight using broken courses, he must have a slight advantage in speed.

[*If B adopted the same tactics, no advantage would result to either side. The real usefulness of the plan of turning very slightly towards an enemy in parallel column lies in its preventing a faster enemy from increasing the range* (*see "The Fast Wing," United Service Magazine, Jan., 1907.*)]

To obtain a certain distance, the side attempting to open distance must turn away from the enemy, and hold him within the after bearing (45° abaft the beam) of the forward turret, in order to keep up the fire from all his guns; to decrease the range, he must turn toward the enemy; but cannot get outside of the extreme forward bearing of the after turret, in order not to lose a large part of the effective fire from his own guns. These limiting bearings of 45° forward and abaft the beam impose the condition that the fundamental position (a course parallel to the enemy) must not be changed more than 45° (4 points) to starboard or to port.

If *A* be faster than *B*, he can always regulate his range after getting it; the slower *B*, no matter how he maneuvers, cannot prevent *A* from carrying out his design. The greater *A's* superiority in speed, the sooner he can carry out his purpose. Even if *B* turns away eight points, *A* will follow, and overtake him.

[*But unless the difference of speed is beyond probability, the slower fleet can maintain a constant range by the method just mentioned for a period long enough to produce decisive results.*]

It is essential, in carrying out the scheme of evoluting in exact column as a battle formation, that the commander-in-chief shall be at the head of the column; he leads his fleet to and regulates the most favorable range for battle, in the manner already explained. He would not be able to do this from a position near the middle of the column; in this case, he would be just as much under the enemy's fire as at the head of the column, with the additional disadvantage that he could not make his plans known to the head of the column fast enough; and, in case a lucky shot carried away his signal mast, he would lose command during the rest of the action. From a position abreast the column on the side opposite the enemy, he would not be able to control his fleet much better; and, eventually, on account of smoke from his own column, he would lose sight of the enemy. It is absolutely essential in a naval battle, where events follow each other so quickly, and every movement of the enemy must be observed and

answered with the greatest accuracy, that the commander-in-chief should be at the head of the battle column.

[*There is room for question as to the best position for the commander-in-chief in action. From the point of view of the preservation of the flagship it would be advantageous to have her lead in the case of the faster fleet and be the sternmost ship in the slower fleet.*

The author's objections to having the flagship abreast the column instead of in it do not seem to be of controlling force, as the commander-in-chief could probably see better from a point outside the smoke of the firing ships than if his were one of them;

FIG. 3.

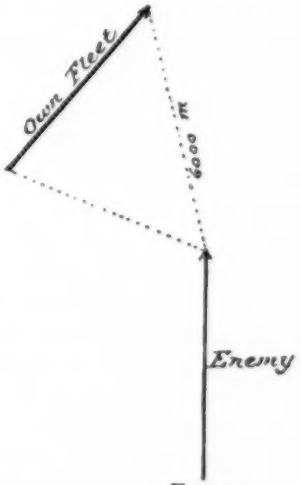


FIG. 4.

certainly the other ships could see him better. The real question seems to be whether or not it is worth while to provide a special ship for this purpose.]

A fundamental principle of battle command is to use one's own fighting strength in its widest possible development; that is, to develop the strongest possible gun-fire while permitting the enemy to keep up the fire from only a small number of guns. To obtain this, an effort must be made to rake the enemy's column; for this, the T position is best suited.

From the T position, or one approximating to it, Fig. 4, the entire fleet can keep up a concentrated and continuous fire on the enemy's leading ship.

If the fundamental position (both lines parallel to each other) be not maintained, and the faster *A* wants to get ahead of and rake the slower *B*, *B* simply turns away; this results in both sides turning in concentric circles, the circumferences and radii of which are proportional. *A*, notwithstanding his superior speed, can never reach the T position. If *A* be only slightly superior in speed, the radii of both concentric circles are very large and only differ slightly from each other.

[*This argument does not take account of the possible, or even probable, proximity of land, which might prevent the slower fleet from turning away.*]

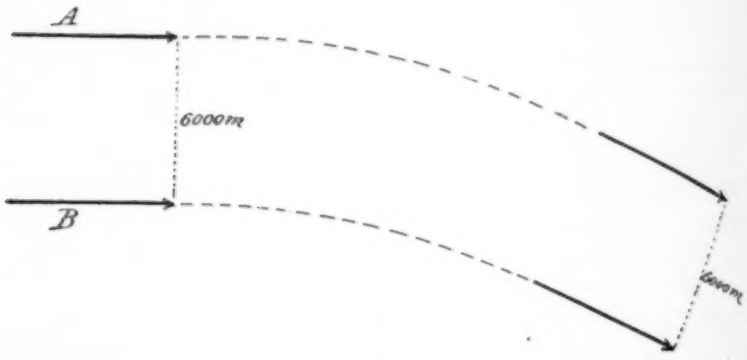


FIG. 5.

If *A*, however, be 6 knots faster than *B*, the radii will be smaller, and *A* can force *B* to make a loop. Such a marked difference in speed between modern fleets engaged in battle could hardly exist; nothing remains for *A*, therefore, but to bring about a great difference in speed, by attempting, on opening the engagement, to destroy the enemy's smoke pipes by a dense fire from his intermediate battery. If these be destroyed, or damaged, the boiler draught is lessened, the steam pressure falls; and the speed therefore decreases. If the head of the column stops, so must the following ships; in this way, one's own fleet might be able to reach the T position. It is quite possible that, by the development of the maximum intensity of fire at the very beginning of the battle, the opposing tactical formation may be entirely or partly broken up by a shower of hits. Even the slower *B* might do this, in so far as he shoots better.

[*Funnel damage is not important so much because of its effect upon speed, which with forced draft would be but little affected thereby, but because of the effect upon the personnel of the escaping smoke and gases.*]

As the moral effect of the first hits will surely be decisive, it must be accepted that the intermediate battery is still far from having played out its part in naval warfare. On the contrary, the gun of intermediate caliber, which, for example, can fire three shots (hardened common shell) of 90 to 100 kg. each in a minute, just at the opening of the engagement, even at 8000 yards distance, will have, not a perforating, but a decisive smashing effect. The high rate of fire of this gun assures a quick determination of the range, by means of which the condition to get the range first is more nearly fulfilled.

Experience has also shown that a battleship with 22 knots trial speed may not be much superior tactically to a ship of the same size with a better battery but with a speed of only 20 knots. Superiority in gun power must be sought; a slower battleship can, by a more accurate and a more rapid fire at the very beginning of the fight, so injure a more rapid enemy that no further use can be made of a superior trial trip speed. The result of this is that, in new construction, too many sacrifices should not be made for speed. It is surely no disadvantage to provide a superior battery for a ship which has from 1½ to 2 knots less speed than that of a probable enemy. For example, the battleship *A*, with a superiority in speed of 2 knots over *B*, will run about 60 m. more than *B* every minute; in ten minutes it will be ahead of *B* by about 600 meters, in an hour by about 3600 meters; the change is therefore very slow, during which *B*, by turning very slowly, can keep the faster *A* on the same bearing, and even win by more accurate shooting. A superiority in speed of even two knots is far from assuring success. Of two battleships of the same displacement, of which one is two knots slower than the other, the advantage rests with the slower one if it have a correspondingly better battery.

An increase in speed of two knots in a large ship requires an increase of machinery weights of about 600 tons—about the same as the weight of two 30.5-cm. turret guns with their ammunition.

Superiority in speed is not decisive even from a strategic point of view. Suppose that the coast line of a sea power is 300 knots

long, and the enemy's fleet suddenly starts to steam from one end of the coast to the other, it will mean a trip of 15 hours at 20 knots, and 13½ hours at 22 knots. Now, is it better to arrive 1½ hours sooner, or to have a corresponding superiority of gun

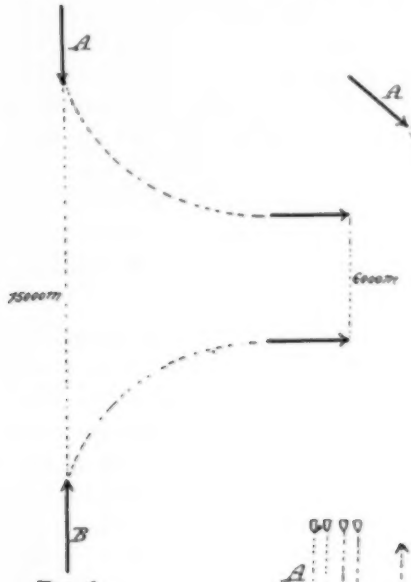


FIG. 6.

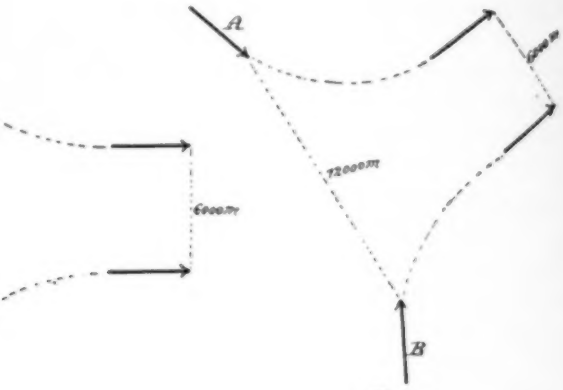


FIG. 7.

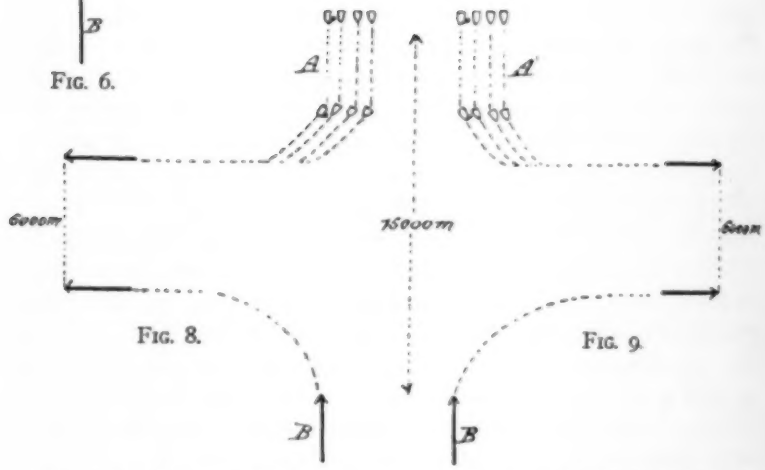


FIG. 8.

FIG. 9.

power in place of this advantage in time? Surely superiority in gun power will be worth more in the following battle than two knots superiority in speed.

However the attack be commenced, whether on opposite courses (Fig. 6), or at an angle (Fig. 7), the opposing fleets will gen-

erally find themselves parallel to each other after the preliminary evolutions. By a frontal attack (in line), one has the advantage of turning one's broadside sooner than an enemy approaching in column from the opposite direction; this has the disadvantage, however, of only too easily keeping the commander-in-chief of *A* in the rear, in case *B* in Fig. 9, for example, should turn to starboard at the right time, and thus anticipate *A's* intention.

[*In Figs. 8 and 9 B is capped and must complete his turn before A's gun-fire becomes effective or he will be under a great disadvantage. This illustrates the advantages which a frontal approach may have under certain conditions.*]

Take two fleets *A* and *B*, of which *A* is the faster. Steering parallel to, and abreast of each other, *A* after a certain time will pass *B*, and will try to obtain the T position. If *B* does not turn

FIG. 10.

away, but keeps straight on, and goes ships left about just as *A* has gotten well ahead and means to rake him, the two rear ships will be at the head of the columns, and *B* will now have the advantage in regard to getting the T position. Therefore even here, *A's* superiority in speed gives him no special advantage.

The *A* admiral can employ this maneuver in the example given in Fig. 9, in order to avoid holding a fatal position at the end of his own column; he orders "slow speed," lets *B* get ahead, and goes ships about, whereby he remains in the lead, while the *B* admiral will find himself at the rear of his column.

[*Whichever fleet turns as suggested is under a tremendous disadvantage during the 3 or more minutes required for the maneuver.*]

Eventually, an important part is played in battle by the rear ships in exact column; therefore just as powerful ships should be placed in the rear as at the head of the column; in all cases, the weaker ships present must be placed in the center, if pro-

vision has not been made to group them in a separate formation. It seems essential that the rear ship should be a flagship, as its position is next in importance to that of the guide; therefore it must have the second in command aboard. This also facilitates a frontal attack (in line), as there is now an admiral in each wing.

If we consider the results of the already discussed tactical evolutions, it is evident that, while maneuvering in exact column on parallel courses, no advantageous tactical position can be gained merely by superiority in speed.

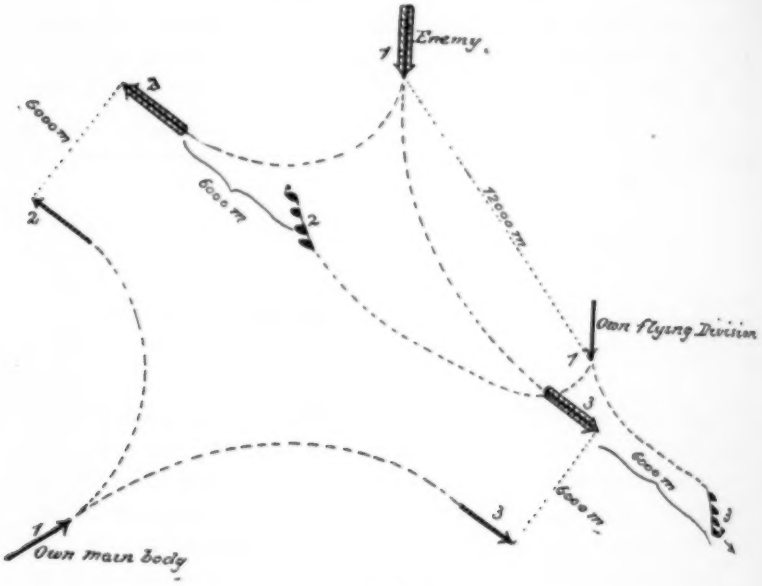


FIG. 11.

[*The author does not take into account torpedo fire, which would certainly be most effective from the leading fleet.*]

As the defeat of the head of the enemy's column is the first and chief aim of the attack, such a distribution of strength must be resorted to, in applying the principles of broadside fighting, that the head of the enemy's column will be held in a cross fire. For this, an effort must be made to sustain only a scattered fire from the enemy, while making use of one's own position to pour in a concentrated fire. For this purpose, armored cruisers can be used.

In doing this, however, the guns on the unengaged side of the enemy must not be given any opportunity to fire; one's own division detached to surround the enemy must not go to the unengaged side of the enemy, but must try to obtain a cross raking fire by taking up a position either ahead or astern of the opposing column (for example, as in Figs. 11 and 12).

If the enemy be reported by the scouts, the problem of the armored cruiser division is to drive back the enemy's vedettes and eventually, after the battle with the scouts, to get into touch with the enemy's main body. The armored cruisers ought to have

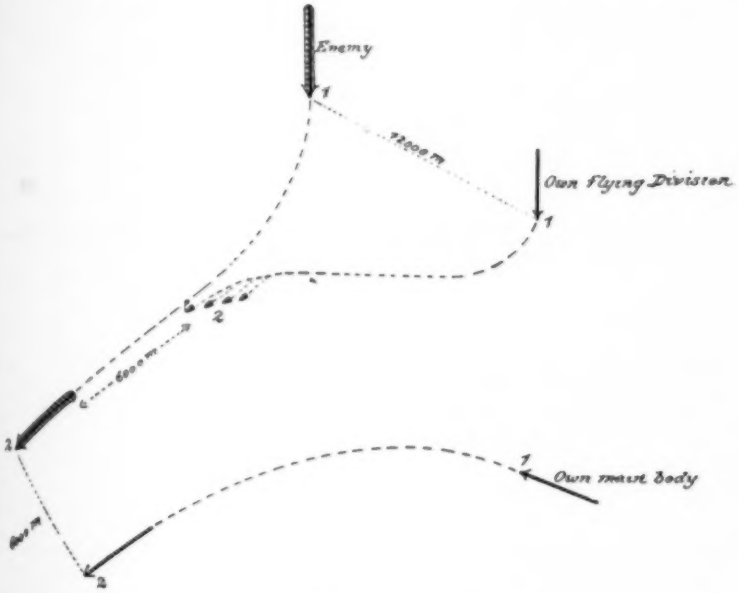


FIG. 12.

great speed, and if possible, have batteries superior to those of the opposing armored cruisers; therefore, guns of the heaviest caliber should be carried by these ships, of course in less number than on battleships.

The armored cruisers, united in a "flying division," can now prepare for their own attack, as, when the enemy is sighted, they can take up their most favorable battle position.

If the flying division should happen to be on that side of the enemy's main body which lies opposite to the intended direction

of attack by its own main body (Fig. 11), it must go, after the enemy turns to starboard (Position 2), or to port (Position 3), either to rear of or ahead of the enemy. The last change carried out by the enemy might be induced by an intention to attack the weaker part of one's own fleet (flying division). In both cases the enemy runs into a cross fire, and the flying division becomes "spotter" for its own main body at the same time; for example,

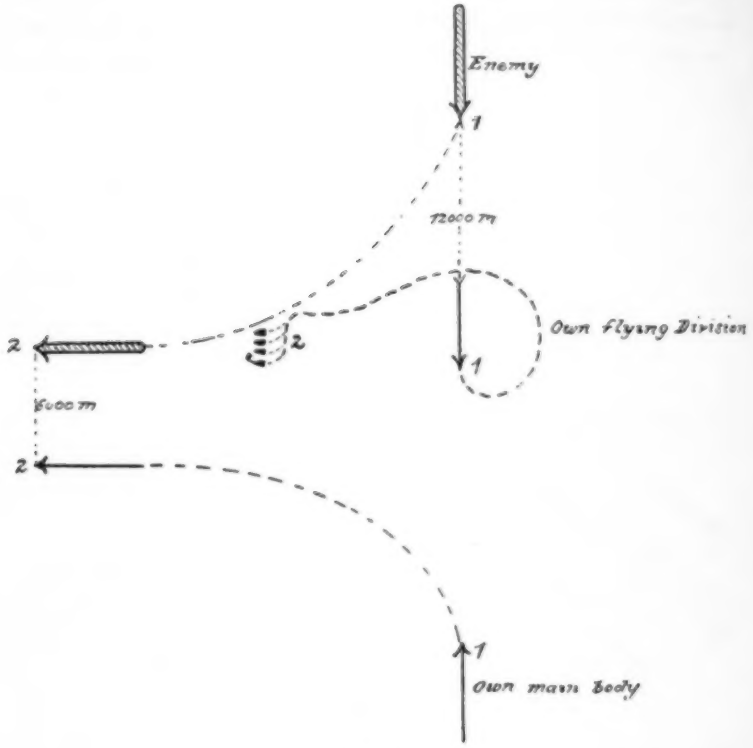


FIG. 13.

hoisting a single flag might mean "Range too great," a flag of another color "Range too small." In Fig. 11, also in those following, Position 1 shows the situation when the two main bodies sight each other, Positions 2 and 3, the situation on opening fire.

If the armored cruiser division should happen to be on the same side of the enemy as that from which its own main body attacks, it must never go ahead of the enemy after the latter

turns away; passing ahead would require a long time; and, in addition, as its course would cross that of its own main body, would result in a masked fire. The flying division could, in this case, attack and rake the enemy from the rear. If, during the course of the battle, the ships go about, it again is ahead of the enemy. The flying division can do valuable service as spotter from the rear also. If the enemy detaches his rear ships to drive off the harassing flying division, he weakens his own main body; besides, the flying division can easily escape this attack on account of its superiority in speed.

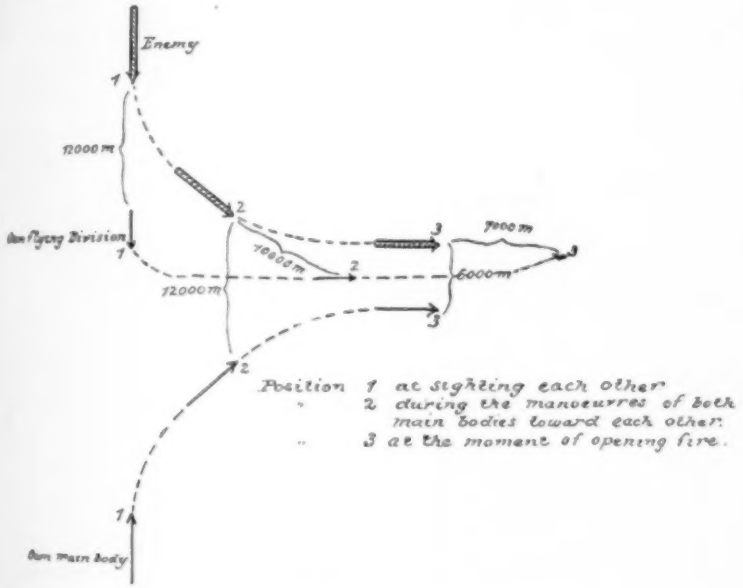


FIG. 14.

If the entire enemy's fleet should turn away from "own main body" eight points, more or less, she will be now flanked by the armored cruisers in her rear (Fig. 12).

Similar conditions hold in Figs. 13 and 14, in which both main bodies sight each other dead ahead; and the flying division, after finishing its scouting work, finds itself ahead of the enemy.

If the flying division be not sent out on scouting duty, it can steam in column abreast the main body (Fig. 15); and, at the very beginning of the engagement, pass ahead in order to rake

the enemy's head; to do this, it must have superiority in speed of 5 knots and over. Therefore, while speed is not tactically important to the battleship, it is of great value to the armored cruiser.

The purposely assumed opposing formations in a single column show the risk a fleet runs in not thinking out favorable tactical positions. A fleet is also at a great disadvantage, which has no armored cruisers to shake off the attacking armored cruisers.

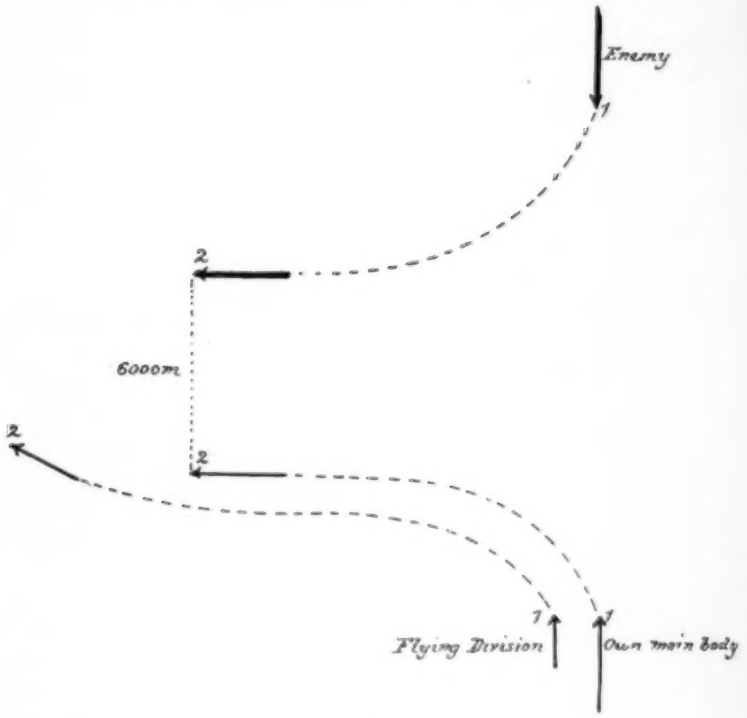


FIG. 15.

[*The foregoing arguments suppose one fleet to be superior to the other, since only one has a "flying division." If each fleet has the same number of ships, the one composed only of battleships must be regarded as the stronger. The scheme of spotting by a detached squadron in battle seems utterly impracticable. For a discussion of the possible uses of a detached squadron see "The Fast Wing," United Service Magazine for Jan., 1907.*]

If both fleets have armored cruisers, a separate battle between these divisions is not improbable; this separate battle would probably precede the great tactical battle as a "scouting fight."

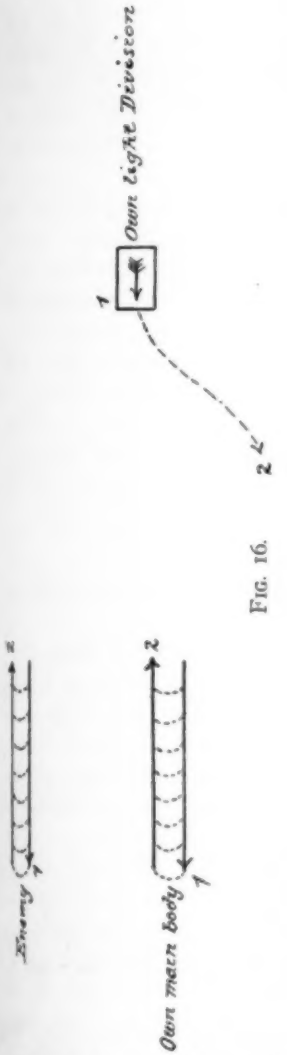


FIG. 16.

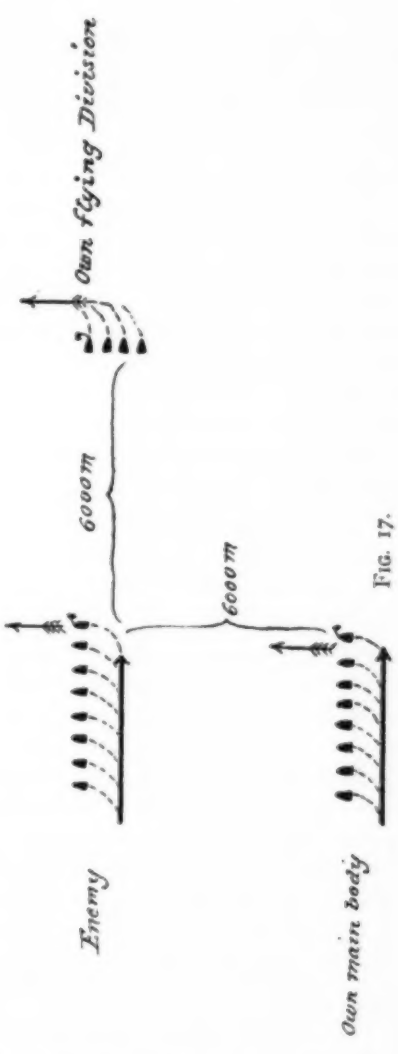


FIG. 17.

Light cruisers, and torpedo boat flotillas take up a position far in the rear before the battle; they serve as a support for their own damaged ships which fall behind, as well as to entirely de-

stroy the enemy's damaged ships which have fallen out. If the battleships go about, these light divisions again take up a position in the rear (Fig. 16). If there be hostile light divisions within the battle area, their chief problem is to destroy them.

It is not improbable that during the action between the two main bodies, separate fights will take place between the cruiser divisions; the battle of Tsushima offers an example of this, during which the Japanese main body fought the Russian battleships while the Japanese light divisions attacked the Russian cruisers and transports.

If, in the first attack, the enemy is caught in a cross fire, he will hardly be able to again escape from this position. Every movement he makes to escape the cross fire is repeated by all of one's "own divisions" simultaneously, following the motions of each division or squadron commander without waiting for a signal, in this way carrying out the plans of the commander-in-chief (Fig. 17). The separate divisions, while remaining true to the principle of concentration of fire in connection with a scattered hostile fire, must not get too far away from each other; and must not take up positions in which they would be firing toward each other. The complete destruction of the enemy's ships which have fallen out must be entrusted to one's own light cruisers; in this way, an increased superiority in fire is obtained over the remainder of the main body.

If, for example, one's own main body, consisting of three divisions, should find itself in a position to rake the enemy (Fig. 18), and the latter should turn toward one's own rear, in order to double on it, it would seem more advantageous for only the two leading divisions to go ships about, and for the third division to keep straight on, thus covering one's own turn by its fire, as firing cannot be kept up during the turn; in this way, a pause in firing will be prevented. When the two first divisions have formed again, the third division joins by a simultaneous turn. It is therefore recommended that the commander of the second division designate the proper place for the third division when the ships form.

[*The enemy would never head as supposed, as he would thus be assuming a "capped" position.*]

The exact column and the temporary line or echelon arising from simultaneous turns amply suffice for carrying out battle

tactics in conformity with the explained principles. If the leading and the rear ships be flagships, they are in the wings during temporary formations.

The only evolutions needed are countermarches and simultaneous turns; extended formations, additional columns, double echelons, wedge formations, double line and squares are rendered unnecessary. Naturally, these battle tactics demand continuous practice in time of peace.

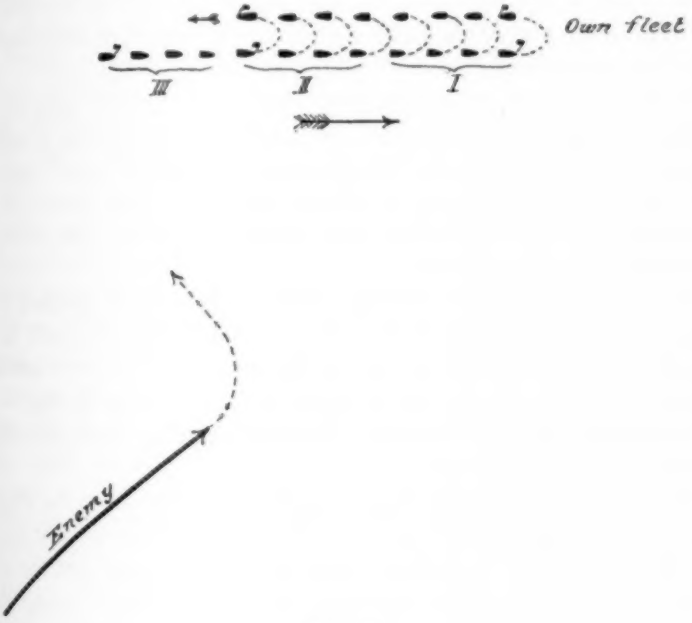


FIG. 18.

The freedom of method of evolutions in exact column offers the additional advantage that very few signals will be needed. Countermarches require no signals; these are only necessary for simultaneous turns. Special formation signals are not required, as all formations are temporary, resulting from simultaneous turns from exact column. Besides, special signals would only be necessary to transmit special orders to the division commanders; even here only a few would be needed, as such orders are general, such as "Attack the van, rear, right or left wing, circle, etc." For this, hoisting a single flag or a pennant suffices;

in exceptional cases a two-flag hoist might be needed. Nor are position signals necessary; the division commander receives an order and takes up the bearing and position which he considers most favorable for carrying out the battle plan. If the personnel of the fleet be properly trained, the purpose of the commander-in-chief is inferred from a brief order of this kind.

[*Signals may not be required when the countermarch is made from the head of the column, but it would seem dangerous to countermarch simultaneously from the heads of the divisions, without some preliminary signal or notice, especially if the formation is a close one.*]

It is a fundamental principle in the formation of divisions and squadrons that all ships which are to maneuver together should be of the same type in the greatest possible degree, so as to have no appreciable difference in battery effect, division speed, and steering qualities. Types of ships which are out of date should form a reserve squadron.

With reference to the number of battleships to be assigned to one division, a narrow limit need no longer be continued, because many formations are no longer required; and with evolutions in exact column, in connection with countermarches or simultaneous turns, it is quite indifferent whether three or more ships make up a division.

England has in her maneuver squadrons from four to five ships in a division; the United States of North America, generally four. Germany formerly built four ships of the same type; but has always built five since the adoption of the latest naval program. Italy, judging by her new construction, has raised the number of ships in a division from three to four. A certain number of battleships of the same type exist to-day; if it be desired to increase the number of ships in a division, it would be a mistake to add older ships. Armored cruisers of the same building period, with the same thickness of armor and armed with the same caliber of, but less guns, as the battleships at present under discussion, offer a remedy to a limited extent. An eventual, slight superiority in speed of these armored cruisers over battleships of the same age is not of so much importance. In accordance with this principle, the *St. Georg* would be placed in the *Erzherzog Karl* division, but the *Kaiser Karl VI* would be in the *Habsburg* division.

With reference to the battle range, it should be stated that this generally depends on the effective range of guns and torpedoes.

The least range that can be used is that a little in excess of the range of the enemy's torpedoes; the maximum range of the enemy's type of torpedo is therefore the minimum battle range to be used in a fleet action. According to present conditions, this should be fixed at 3500 meters; but in the near future it will probably reach 4000 meters.

[*It must not be forgotten that for fleets on parallel courses, effective torpedo range is very much greater for the leading fleet than for the rear one. Also the range assumed by the author is that of the torpedo at a speed near its maximum; at reduced speed the torpedo range is very much greater, and advantage can be taken of this fact by the leading fleet.*]

It is not so easy to decide upon the maximum fighting range; this is limited, in the first place, not only by the distance at which good spotting is possible, but also by the distance at which the range finder still gives reliable readings; the practice is, to place this at from 7000 to 7500 meters. The effective ranges of guns are also most important; the following table shows this for the 30.5-cm., 45-caliber gun, with a projectile weighing 445 kg., initial velocity 800 m., and a muzzle energy of 14,700 mt.

Distance in Meters	Final Velocity in Meters	Penetration of K. C. Armor in mm.
4000	633	351
5000	594	311
6000	558	283
7000	520	251

It is evident that, with this powerful type of gun, capped shell can be used with advantage at even over 7000 meters, as even beyond that distance the final velocity is somewhat greater than 500 meters. With reference to the penetration of an enemy's armor belt 250 mm. thick, 7000 m. seems the maximum battle range. If it be considered that the thickness of the armor belt of the ships being built is from 270 to 300 mm.; further, if oblique impact be considered, the practicable maximum fighting range becomes from 5500 to 6000 meters, in order to still expect good results from armor-piercing projectiles of a 30.5-cm. gun.

If perforating effects be abandoned, hardened common shell, with their large bursting charge, would have a powerful smash-

ing effect even at a far greater distance; and the effective fighting range could, in this sense, be increased even to 8000 m; the question must be asked, however, whether this great range can bring real advantages. It is well known that the errors of guns increase with the range; and small unavoidable errors—for instance, that due to the rolling of the ship—decrease the probability of hitting more and more as the distance increases. Inaccurate spotting accompanies inaccurate shooting; so that, besides the necessarily slow fire from heavy guns, getting the range will take so long, that not only is a long time required, but also a great expenditure of ammunition. So that even for smashing effect it is an advantage not to get farther away than 6000 meters, in order to waste as little time as possible.

In order to obtain the greatest number of hits possible, it is necessary to envelop the enemy in a continuous shower of shots, for it is only through accurate observation of a continuous fire that conclusions can be reached about the certainty of hitting; that is, it can then be decided whether the range has been found or not. Take, for example, a ship which can use eight 30.5-cm. guns (*Dreadnought* type) on the broadside, and whose aimed regulated rate of fire is one shot every two minutes, in ten minutes after opening fire 40 shots will be fired; allowing 10 per cent of hits—a very high rate for war time—4 hits are made in the first ten minutes of battle. Now, compare with this an equally large and just as strongly armored ship, which carries on the broadside six 30.5-cm. and six 19-cm. guns. With the same rate of fire from the heavy guns, and a rate of 5 shots in two minutes for a 19-cm. gun in aimed and regulated fire, in ten minutes after opening fire, 30 shots from the 30.5-cm. and 150 shots from the 19-cm. guns will be fired. Allowing 10 per cent of hits with both classes of guns, three hits with the 30.5-cm. and 15 hits with the 19-cm. guns will be obtained. But if the 30.5-cm. gun actually makes 10 per cent of hits, no mistake will be made in giving twice that percentage to the 19-cm. gun, because, on account of the higher rate of fire, the range can be obtained more rapidly, and the time up to the next change of distance could be better used; we can, therefore, in our case, take, instead of 15, possibly 30 hits with the 19 cm. gun.

[*The assumption that the 19-cm. gun fires five times as fast as the 30.5-cm. is entirely untenable,—twice as fast is very much*

nearer the truth. Neither is it correct to allow twice as great a percentage of hits for the 19-cm. as for the 30.5-cm., even supposing, as the author does, that the fire of each class of gun can be regulated separately. At such ranges as the author is considering, the accuracy of the larger gun must be the greater of the two.]

It must also be remembered that the ships' crews are not dummies, but are made up of men with nerves and a decided instinct of self-preservation; the moral effect will therefore be vastly different, whether the ship is hit only four times or thirty-three times in the first ten minutes of battle. The 19-cm. hits will, of course, mean no catastrophe; and no armor penetration must be expected from these guns at a range of 6000 m.; therefore, by raising the mean point of impact, an endeavor must be made to obtain a smashing effect against the control stations, the smoke pipes, and the superstructures.

In twenty minutes of battle, the first ship would make 8 hits with her 30.5-cm. guns, the second, 6 hits with her 30.5-cm., and 60 hits with her 19-cm. guns. It would be hard to decide whether two hits more with the heavy guns would be worth more than 60 hits with the 19 cm. guns. It is certain that, as far as moral effect is concerned, the numerous 19-cm. hits would have a very demoralizing effect. The ship with an intermediate battery also has more chances of damaging the enemy's control stations, telegraph and telephone apparatus at the very beginning of the fight.

[*The comparison should be between eight 30.5-cm. hits on the one hand and six 30.5-cm. and less than twelve 19-cm. hits on the other. The fact that exposed positions and apparatus can be disabled by small projectiles is a better argument for the retention of the small R. F. guns on battleships than for the use of guns as large as the 19-cm. It must also be considered that the greater the number of guns the greater the complexity and consequent liability to damage of the fire control system.*]

With regard to the maximum battle range of about 6000 yards for the 30.5-cm. gun, it will be necessary, even for a ship mounting only heavy guns, to rather lessen than increase the range, in order to increase the probability of hitting, and to defeat the enemy quickly, for the stronger will avoid a long and halting battle with the weaker so as not to give the latter much oppor-

tunity for chance hits. At 6000 meters and less, the intermediate battery is offered many targets, not to perforate but to destroy, which affect the enemy's fighting capacity. For this required quick and complete destruction, the 12-cm. and 15-cm. guns no longer serve; the best for this purpose is the 19-cm. gun; greater calibers fire too slowly. If it be desired to lower the enemy's speed by damaging his smoke pipes, as was mentioned in the beginning when treating of tactical advantages, mounting intermediate batteries on battleships is absolutely essential. The following tables show, for a 19-cm., 45-caliber gun, with a projectile weighing 90 kg., 870 m. initial velocity, and a muzzle energy of 3600 mt., no useful penetration at 6000 m., therefore hardened common shell, with their large bursting charge (6.5 kg.) are of great service as smashing projectiles.

Table for a 19-cm., 45 caliber gun.

Distance in Meters	Final Velocity in Meters	Penetration against K. C. Armor in mm.
4000	558	120
5000	494	102
6000	439	86
7000	390	72

If, instead of the 19-cm. gun, a 24-cm. gun be used as an auxiliary, great disadvantages result. As a heavy gun, the 24-cm., in comparison with the 30.5-cm. gun, is far too weak; as an intermediate gun, it is too unwieldy and fires much too slowly, with the result that getting the range is as tedious as with the 30.5-cm. gun.

[*The author's ideas as to relative rapidity of fire are wholly at variance with the results of recent experience.*]

Table for a 24-cm., 45-caliber gun with a projectile weighing 215 kg., 800 m. initial velocity and 7000 mt. muzzle energy.

Distance in Meters	Final Velocity in Meters	Penetration against K. C. Armor in mm.
4000	583	167
5000	531	150
6000	494	132

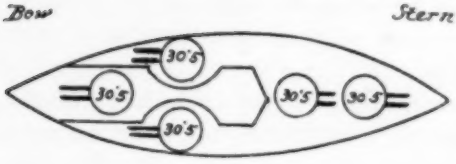
As the table shows, the 24-cm. gun can be used at the close distance of 4000 m., but can no longer be used against a modern armor belt at a battle range of 5500 to 6000 m.; but, at the very best, against casemate armor. Now then, the question arises,

whether it would be well to introduce, to solve special problems of this kind, a special heavy gun, which does not fire much more rapidly than the 30.5 cm. gun.

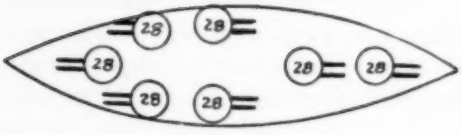
In order to obtain the greatest possible number of hits with the 30.5 cm. gun against the enemy's armored belt, the waterline must not be aimed at, because half of the shots, even with the right range, will fall short in accordance with the laws of dispersion; it is far better to aim at the middle of the whole target presented. There will be as many hits above as below the mean point of impact; that is, the hits with the 30.5 cm. guns will fall, on account of the dispersion, not only on the armor belt, but also on the casemate armor. Bearing this in mind, the 24-cm. gun can be abolished for the destruction of casemate armor; and, in its place, the 19 cm. gun, which is much more handy, and fires more rapidly, can be brought into use as a smashing gun.

The conclusion to the discussion of the effect of guns of different calibers at the most favorable ranges is that the most favorable future battle range—with the condition that the introduction of heavier guns will also bring about heavier armor—will always be within the limits of good spotting, and favorable penetration, but outside the torpedo range; therefore it will be from 4000 to 6000 meters. Fighting at close range, by which is meant about 4000 meters, in order to avoid being hit by torpedoes, will also assure more speedy success to the side which has the more powerful battery. The battle of Tsushima offers the most recent and the best example of this. Although the English armored cruiser divisions, during the last fleet maneuvers, fought a battle lasting two hours at very large ranges, the mistake in this fight was that the firing, for this very reason, was wild; there is no proof here of the necessity of great battle ranges.

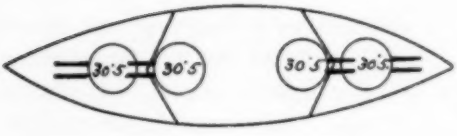
If the sketches of the batteries (Fig. 19) of the most recent types of large battleships be considered, it will be seen that England, Germany, and North America excel in heavy guns. The battery of the French *Danton* will be seen to have been unfortunate, according to the above-developed ideas, in the choice of the 24-cm. gun for the intermediate battery. The abundant use of the 20 cm. gun on the proposed Russian battleship is very striking. It is to be inferred that the Russians have adopted this battery as the result of their experience in the battle of Tsushima, in which they learned the smashing and demoralizing effect of



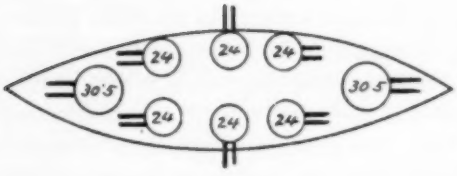
Dreadnought.
18,000 tons displacement.
21 knots speed;
28 cm. armor belt:
10 30.5-cm. guns;
5 torpedo tubes;
ram (error).



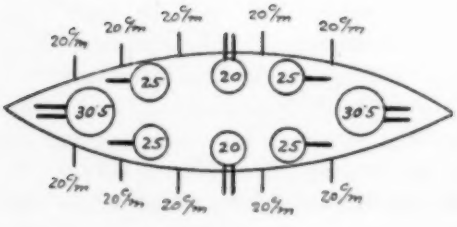
Ersatz Sachsen.
19,000 tons displacement.
19.5 knots speed.
? armor belt;
14 28-cm. guns;
6 torpedo tubes; ram.



South Carolina.
16,000 tons displacement.
20 knots speed;
30 cm. armor belt;
8 30-cm. guns;
2 torpedo tubes; ram.



Danton.
18,000 tons displacement.
19 knots speed;
25 cm. armor belt;
4 30.5-cm. guns;
12 24-cm. guns;
5 torpedo tubes; ram.



Russian Type (according to Jane).
16,500 tons displacement.
19.8 knots speed;
28 cm. armor belt;
4 30.5-cm. guns;
4 25-cm. guns;
14 20-cm. guns;
4 torpedo tubes; ram.

FIG. 19.

the intermediate battery. The information at hand about the new Japanese 19,000-ton battleships is of no value; it is rumored that the 30.5-cm. gun will not be the only one installed; and it is therefore possible that the Japanese will also adopt a large intermediate battery for their new ships.

[*The assumed battery of the new Russian ship seems to be quite as hypothetical as that of the Japanese ship.*]

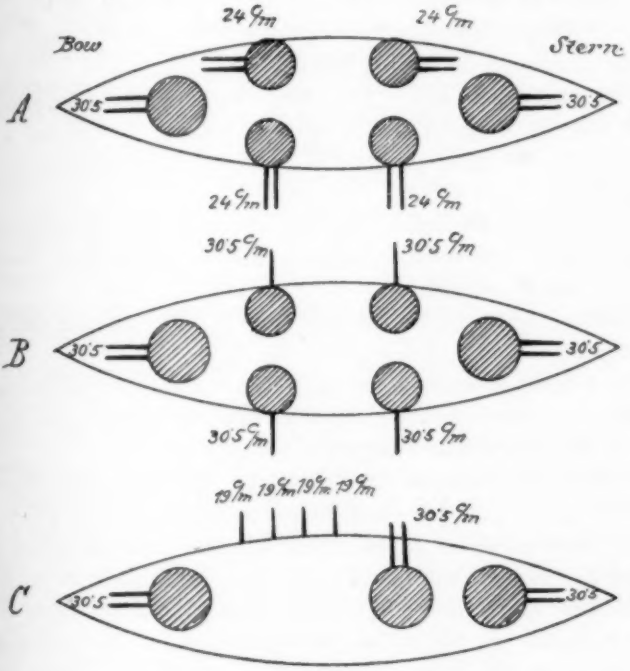


FIG. 20.

(Note.—The latest information about the Japanese 19,000-ton ships, *Satsuma* and *Aki*, is that they will carry four 30.5-cm. and twelve 25-cm. guns; the large armored cruisers *Tsukuba* and *Ibuma* have four 30.5-cm. and twelve 15-cm. guns; both types, besides, will be armed with 12-cm. guns, and five torpedo tubes each.)

If we now turn to the question of the batteries of battleships and armored cruisers, we must, in addition to the many arguments in favor of the principal gun, consider the armaments of the battleships of neighboring states, in order at least to aim at equality.

As a heavy gun, only the 30.5-cm. need be considered at present; for the enormous effect of this gun justifies its widest use. The question now arises, whether to install only heavy guns, or an intermediate battery as well.

Let us compare three ships of the same size, and same thickness of armor, but with different batteries (Fig. 20). The total weight of the battery is the same in each case. It is easy to see the superiority in battery of *B* over *A*, also that of *C* over *B* or *A*. Type *A* shows the most unfavorable battery scheme.

Type *C* has the following advantages:

1. The number of heavy guns that can be used on the broadside is the same in *B* and *C;* with reference to *A*, the number is also the same, as one 30.5-cm. gun is equal to, if not superior to, two 24-cm. guns.

2. In place of the heavy useless turret on the unengaged side, a considerable intermediate battery can be mounted on *C* without any increase in weight.

3. There are no high outboard turrets, whereby the ship gains in stability.

4. In a fight between *B* and *C*, *C* cannot only bring into action the same number of heavy guns as *B*, but four 19-cm. guns in addition; *C*, therefore, has a superior battery.

[*If it is advantageous to exchange the two after broadside 30.5-cm. guns of B for the pair of 30.5-cm. guns in a turret on the middle line as in C, an equal advantage would result from putting the two forward broadside guns in another turret on the middle line forward. The comparison should therefore be between eight 19-cm. guns, four on each broadside, and two 30.5-cm. guns in a middle line turret. Thus modified C would have a broadside fire greater than that of B by two 30.5-cm. guns.*]

There are no special technical difficulties to be overcome in mounting three turrets in the keel line on a correspondingly long modern ship. The longitudinal framing suffers just as little as by the installation of two turrets in the keel line. With reference to the distribution of space below, the narrow ammunition passage of the middle turret can be located between the boiler and engine rooms, without making the steam piping too long.

The principal advantage of the three-turret system lies in the fact that every heavy gun can be used on the broadside (the chief battle direction); and it seems advantageous to obtain this to

sacrifice a little in the distribution of space below. The bow and stern fire, which would have no value in the development of battle tactics, is, as before, represented by only one heavy turret. With reference to the arc of train, it is entirely satisfactory if the middle turret can be worked within the above discussed limiting bearings of the forward and after turrets; that is, from 45° forward to 45° abaft the beam.

[*By raising the level of the two center middle line turrets, bow and stern fire may be doubled, as in the South Carolina design, without diminishing the broadside fire.*]

Four thousand to six thousand m. was decided upon as the most favorable battle range; the necessity of a close action (about 4000 m.) was also shown. Both of these conditions justify the installation of an intermediate battery. Thus, if, as sketched in Fig. 20, the number of heavy guns can be reduced, without any loss of heavy broadside fire; and a numerous intermediate battery be brought into action in addition, without increasing the displacement of the ship, superiority must without question be yielded to type *C* (Fig. 20).

[*No adequate proof of the necessity for close action (about 4000 m. range) has thus far been given.*]

The control stations, smoke pipes, superstructures, boats, light bridge battery, etc., offer the 19-cm. guns a wide usefulness at great distances; at 4000 m. they will attack the least protected parts of the enemy. Only hardened common shell must be used with this gun to produce its maximum destructive effect; for in that way penetration will be more advantageously replaced by the smashing effect.

[*It is presumed that by the words translated "smashing effect" the author means the effect of the fragmentation of the shell on impact.*]

In an interview, Admiral Rojestvenski stated that his crews were totally demoralized by the fire from the Japanese intermediate guns. Hits in quick succession splintered and destroyed everything in their path, innumerable fires broke out, even the coat of paint began to burn; and the Russian ships looked more like seas of flame than fighting machines.

The Japanese are convinced by this that they owed a good share of their victory to the success of the intermediate guns; they declare that at short range (3500 m.), there were no misses.

It is of interest to mention here that the Japanese 15-cm. guns are not trained by a hand wheel, but by a special transmission through two pedals—as in a bicycle. The gun pointer sits in a spring saddle, with his feet bound to the pedals; one hand is on the elevating wheel, and the other on the firing key; his forehead is pressed against a strong rubber buffer on the telescope; it is thus readily seen why these pointers did such splendid work; they were not only well drilled, but also bound fast to and formed one person with their guns.

[*In considering the value of intermediate battery guns, the character of the probable target is of controlling importance. Against a properly armored ship of the design now generally approved, having a homogeneous battery of 12" guns in turrets, intermediate battery guns would be quite ineffective.*]

The 47-mm. and 37-mm. rapid fire and machine guns were not found efficient as torpedo boat defense guns in the Russo-Japanese war; the Russians stated that their effect was too small —their projectile was too light. Both the Japanese and the Russians consider that the 7-cm. gun will be the smallest that will be mounted on ships in the future; in fact, the new Japanese 400-ton destroyers will be armed with six 7.6-cm. (two long and four short) rapid fire guns.

Defense against the enemy's torpedo boats by means of shrapnel from the intermediate guns is very unsuccessful, because the range changes so rapidly that it is almost impossible to accurately set the fuse; and, besides, the fragments have even less effect than with the 47-mm. gun. The torpedo boat must therefore be attacked with effective shell from rapid fire guns. The 7-cm. gun with a projectile weighing 5 kg. is the lowest limit; the highest is determined by the handiness of gun and projectile. The 15-cm. and the 12-cm. guns need no longer be considered, because their fixed ammunition was too heavy; and for service and safety reasons, they became again separately loaded guns. The proper anti-torpedo boat gun, however, requires fixed ammunition, as well as semi-automatic breech closure, in order to maintain a rate of about 20 shots a minute. The largest caliber which fulfills these conditions is the 10.5-cm. gun; with a projectile weighing 18 kg., the fixed ammunition would weigh about 25 kg. It is well to remember that this weight of fixed ammunition might be too heavy for a long continuance of fire; and the gun's rate of fire might easily be decreased on account of the weariness of the loaders.

It can be safely said that a shell weighing 10 kg., with an initial velocity of 900 m. will suffice for defense against torpedo boats for a long time; it is therefore reasonable to give the preference to this particularly handy ammunition. A caliber of 9 cm. corresponds to this weight of shell; the fixed ammunition would weigh 15 kg.

[*The use of shrapnel, or even possibly canister, from the heavy guns as a defence against attacking torpedo boats, seems worth consideration.*]

Destroyers will continue to be built larger and stronger; and must, in a short time, merge with the Scout Type; the intermediate battery (19 cm.) will serve to attack these ships which are provided with a protective deck. The 10.5-cm. gun is too weak as an intermediate gun; and too heavy for an anti-torpedo boat gun; it has the same thankless rôle as the 24-cm. gun. If there are 19-cm. guns aboard, the anti-torpedo boat guns need no longer play an auxiliary part as intermediate guns, and—as already explained—the particularly handy 9-cm. gun can be installed as an anti-torpedo boat gun in place of the 10.5-cm. If as many 9-cm. guns were mounted as 10.5-cm. were proposed, the saving in weight would permit a double allowance of ammunition to be carried. The existing data on these two light calibers are given for comparison.

	10.5 cm., 45-Caliber	9 cm., 45-Caliber
Caliber	105 mm.	90 mm.
Weight of gun	2000 kg.	1600 kg.
Weight of carriage and shield	2800 kg.	2300 kg.
Weight of projectile	18 kg.	10 kg.
Weight of fixed ammunition	25 kg.	15 kg.
Weight of allowance (200 rounds)	5000 kg.	3000 kg.
Initial velocity	850 m.	900 m.

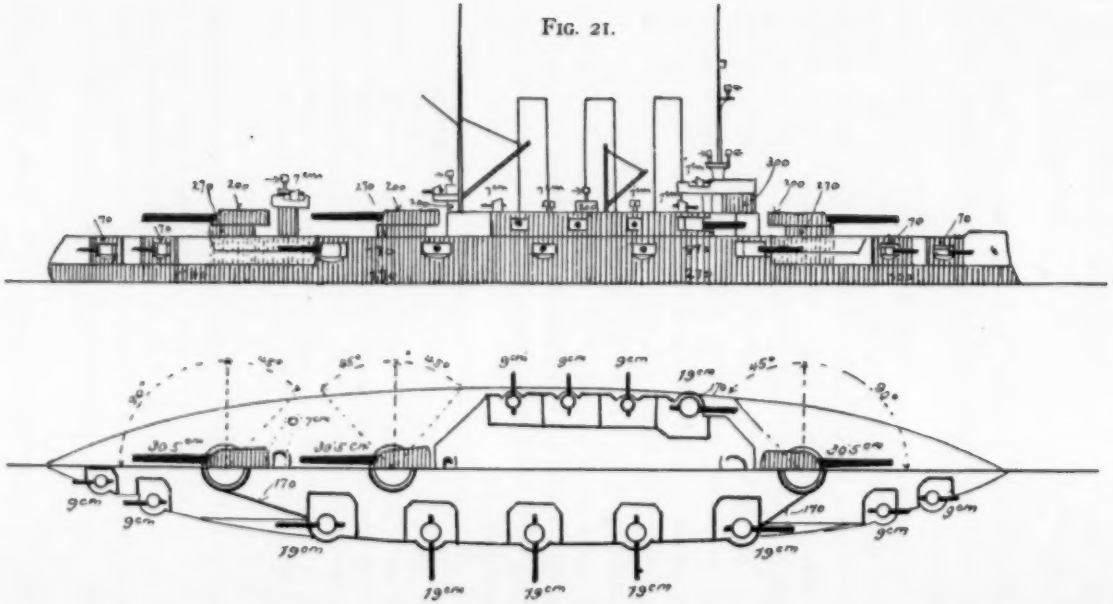
Seven-cm., 45-caliber (66 mm.) guns belong on the bridge decks and in the tops; in future, guns of less caliber will not be used.

Fig. 21 illustrates a type of modern battleship in accordance with the ideas herein developed; both torpedo tubes and ram are retained, in order to permit the captain to use these weapons when possible.

Fig. 22 illustrates an armored cruiser; Fig. 23, a modern destroyer.

The use of the armored cruiser both before and during battle has already been explained; the supplementary type is the large

FIG. 21.



DATA.

Waterline length, 143 m.
Beam, 23 m.
Displacement, about 17,000 t.
Speed, 21 knots.
Armor belt: amidships, 270 mm.; at ends 100 mm.; protective deck, 50 mm.

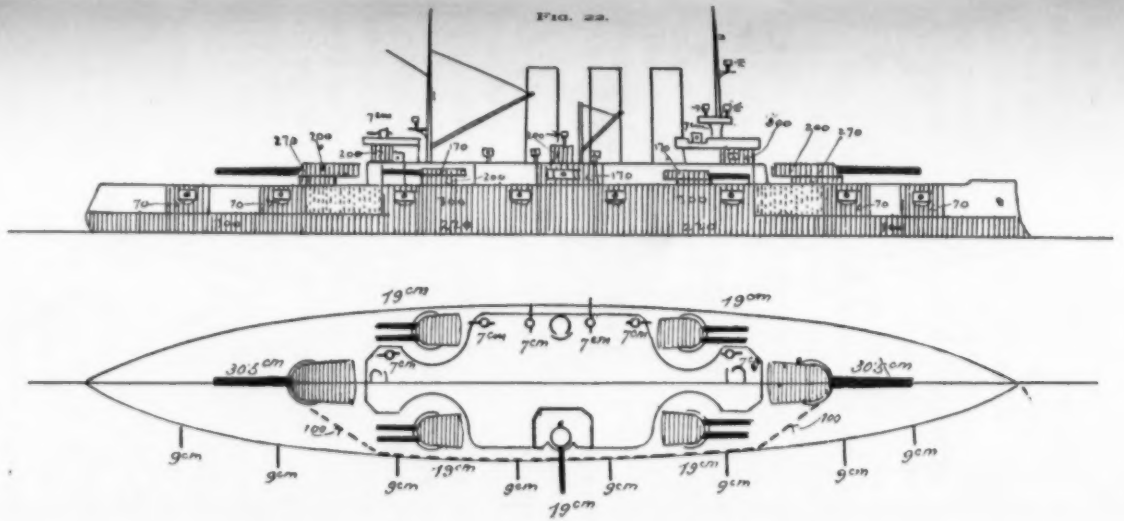
Battery side armor, 170 mm.; forward and after athwartship armor, 170 mm. 4 45-cm. broadside under water torpedo tubes, ram, 7 90-cm. searchlights. 6 30.5-cm., 45-caliber guns in three turrets, whose barbettes are 270 mm. and the turrets 200 mm. thick. 12 19-cm., 45-caliber guns in separate casemates, all with 170 mm. armor. 14 9-cm., 45-caliber guns in separate casemates all with 70 mm. armor. 14 7-cm., 45-caliber guns on bridge deck and bridges. Conning-tower armor, 300 mm.; all other control stations, 200 mm.

FIG. 22.

Displacement, about 17,000 t.
Speed, 21 knots.
Armor belt: amidships, 270 mm.; at ends 100 mm.; protective deck, 50 mm.

thick. 12 19-cm., 45-caliber guns in separate casemates, all with 170 mm. armor. 14 9-cm., 45-caliber guns in separate casemates all with 70 mm. armor. 14 7-cm., 45-caliber guns on bridge deck and bridges. Conning-tower armor, 300 mm.; all other control stations, 200 mm.

Fig. 22.



DATA.

Waterline length, 130 m.
Beam, 21.0 m.
Displacement, about 11,500 t.
Speed, 23.5 knots.
Armor belt: amidships, 220 mm.; at the ends, 100 mm.; protective deck, 50 mm.

Battery side armor, 100 mm; forward and after athwartship armor, 100 mm.

4 45-cm. broadside under water tubes, ram, 6 90-cm. searchlights. 2 30.5-cm., 45-caliber guns in 2 turrets, with barbettes 270 mm., and turrets 200 mm. thick.

10 19-cm., 45-caliber guns: 8 in 4 turrets with 200 mm. barbettes and 170 mm. turrets. 2 in separate casemates with 170 mm. armor.

16 9-cm., 45-caliber guns. 8 in broadside, behind the 100 mm. armor. 8 for bow and stern fire behind 70 mm. of armor. } all in separate casemates.

16 7-cm., 45-caliber guns on the upper deck and bridges. Conning-tower armor, 300 mm.; all other control stations, 200 mm.

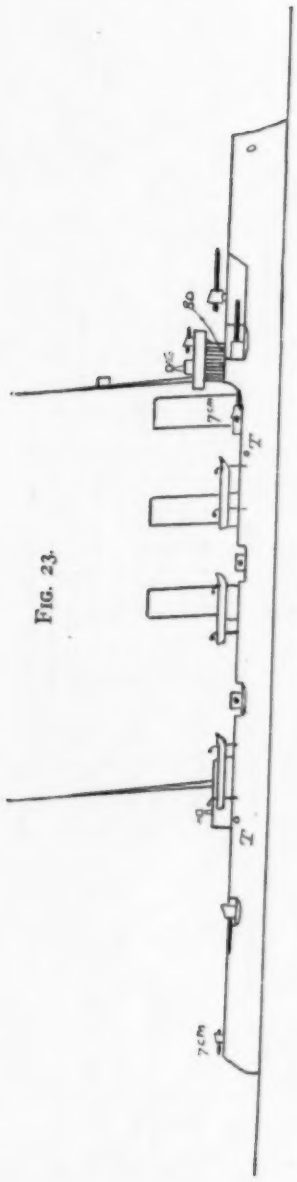
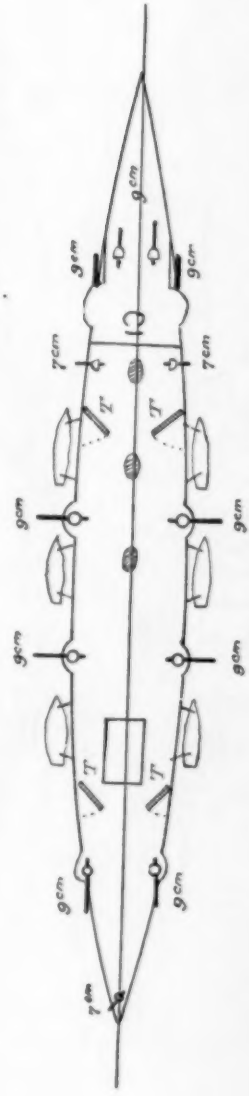


FIG. 23.



DATA.

Waterline length, 95.0 m.
Beam, 10.5 m.
Displacement, about 2000 t.
Speed, 28 knots.
Conning-tower armor, 80 mm.
Protective deck, 50 mm.

10 9-cm., 45-caliber guns, 4 of them bow chasers. 3 7-cm., 45 caliber guns, 2 forward and 1 aft. 4 45-cm. above water torpedo tubes. 3 searchlights (2 on bridge, 1 on deck house, aft).

destroyer, which has not only its own special work, but must also be used as a scout and for general information service.

Armored cruisers should have a high speed above all things; their armor protection must be heavy enough to make it possible for them to take part in the general engagement. However, their batteries should only be of such a character as will permit them to act as a support to the battleships taking part in the action. As an example, the action of the second Japanese division, under the command of Vice-Admiral Kamimura, in the battle of the Sea of Japan is given: This division consisted of six armored cruisers (Asama class); and did not carry heavy guns; nevertheless, they were kept in the formation on account of their defensive strength (178 mm. armor); and supported with great effect, by an overwhelming fire from their 20-cm. and 15-cm. guns, the fire from the heavy guns of Togo's battleships.

The intention has frequently been discussed to locate the principal guns of an armored cruiser aft; and, since the beginning of the year, various experiments have been made by England with the cruisers *Crescent* and *Royal Arthur* of the *St. Georg* type (7700 tons); two 15-cm. guns were mounted forward, in place of the 23-cm. gun; a 23-cm. gun was mounted aft. At about the same time, a 32-cm. gun was mounted aft on the Japanese cruiser *Matsushima* (4300 t.); and to replace it, two 12-cm. guns were mounted as bow chasers; the arrangement is just the opposite aboard her sister ships the *Hashidate* and the *Itsukushima.*

The difference in the bow and stern guns of the Italian *Garibaldi* type is worthy of note; these ships carry one 25-cm. gun in the forward turret, and two 20-cm. guns in the after one. However, only these modest experiments have as yet been made. It seems logical to have equal strength forward and aft, as armored cruisers cannot only be chased themselves, but will have to chase at least just as often; in a broadside battle, bow and stern guns are equally serviceable.

In conclusion, one short remark will be made about the value of small and old armored cruisers.

Small, as well as armored cruisers of an old type, are generally designated as coast defense ships.

The ideal coast defense is to meet the attacking enemy at sea, and ward off his attack, in order to free one's own coast from all the horrors of war. But the small armored coast defense ship does not serve for such offensive work against modern sea-going

battleships. A battle under one's own land batteries is hardly to be expected, as the enemy would not get so close to the land on account of the danger from mines; and can still retain command of the sea close by but beyond the range of the batteries. Even if a fight should take place near the land, within the range of the guns of the coast defense ship, the sea-going battleship would win very quickly on account of her superior battery. Therefore the small cheap armored ship deserves the name "coast defender" just as little as an old corvette deserves the name "cruiser." Only ships of the same displacement, with the same armament, and the same armor as sea-going battleships can be considered as coast defense ships. As the coal capacity of the coast defense ship need not be as great as that of a sea-going battleship, the saving in weight of coal may be used to strengthen the under water armor, or to make a treble bottom, in order to warrant a successful issue against mines and submarines, which now play such an important part in coast warfare. A small armored ship, on account of her less protected under water body, would be much more likely to fall a victim to submarine weapons than a large one. Only on a large battleship (17,000 to 18,000 tons) is it possible to assign such weights of construction as will result in an approximation to the ideal non-sinkable state.

[*The author can hardly mean to advocate the retention of first-class battleships in home ports for coast defense.*]

The use of old battleships as blockade ships for the purpose of harbor defense also seems doubtful. Generally moored head and stern, a blockade ship would be apt to fall a victim to the enemy's torpedo boats and submarines at the very beginning of the war. It is also doubtful if such ships could withstand many shots from modern guns, on account of insufficient armor.

If, for various reasons, the guns of the harbor defense ship could not be spared, it would seem to be much more advantageous to land them, and mount them ashore behind earth works; in this way, the additional advantage is obtained that all the guns can be brought into action, while, on board, that part of the battery (in casemate ships, one-half) on the unengaged side could not be used. Besides, by giving up the use of easily destroyed harbor defense ships, the enemy is deprived of a chance of a cheap partial victory, leaving out of consideration the fact that such vessels can only have a demoralizing effect on their own crews.

E. v. Rz.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

FLEET TELEPHONY.

By COMMANDER BRADLEY A. FISKE, U. S. Navy.

In 1895 I went, unofficially, on board one of our new battleships, at anchor off Staten Island. I got into conversation with the captain on the quarter deck, and after awhile the conversation turned to the subject of fogs. Something betrayed me into the indiscretion of suggesting the scheme I am about to describe. I had had the idea in my head for a long time, but had not dared to mention it.

The captain did not understand my plan for a few moments; but when he did, he raised both hands above his head and disappeared down the cabin hatch.

The scheme I suggested was that, when an admiral saw a fog coming up, he should make a signal, in obedience to which the ships should form exact column; and each ship should pay out over the stern an insulated wire supported by a buoy, which buoy should be picked up by the ship astern, and the wire connected to the end of a permanent wire which should run the length of that ship to the inboard end of the wire which that ship paid out astern. This permanent wire was to be part of a circuit, including a separate battery for each ship, and two sets of telephones, one set placed in the chart house, and the other in the cabin. In order to prevent the breaking of the wires between the ships, I suggested that the wire paid out astern should be about 800 yards long, and that the spare wire at the end should be put around a reel on the bow of the ship astern, which should automatically reel in the wire, or pay it out, like a small towing engine. I pointed out that this wire could have marks on it; and that by noting these, and the direction in which the wire tended, one could tell the distance and direction of the ship ahead in the thickest

fog with extreme accuracy. I also pointed out that, even if a wire broke between any two ships, the ships on each side of the break could still talk together; and that the ship astern of which the wire broke could pay out another wire in a few minutes.

Since that time I have suggested the scheme occasionally, but have never got anybody to endorse it, until now. But I have just received a letter from Commander Oliver, suggesting the plan himself, saying that he proposed it to Admiral Manney in 1903, and asking me if I could not see my way to testing it. As I cannot, it occurs to me that a suggestion in the Naval Institute may reach somebody who can.

Last summer, when in command of the *Minneapolis* off Virginia Beach, I tried the plan in a crude way between the *Minneapolis* and a steam launch. The plan worked very well for about five minutes, during which time the *Minneapolis* and the steamer were going about five knots, the steamer about 300 yards astern. There being no reel available for the wire, a man sat in the bow of the steamer, and held the wire in his hand, having about 10 fathoms slack in the steamer, and paying out or hauling in the wire, in such a way as to keep a short slack bight under the bow of the steamer. Of course, the friction of the wire in the water kept it taut in the water; and the man in the steamer simply held up the slack wire running from his hand directly down to the water, so that there was no strain on the wire, except that due to friction in pulling it through the water. But the wire was a condemned length of portable wire, about No. 16, and it had been broken in several places and spliced; therefore, it was not at all suitable for the experiment, and it soon broke.

Last September in New Haven, just before going to the Oyster Bay Review, I described this experiment to Commander Colwell of the *Denver*, and asked him if he would not try it between the *Minneapolis* and the *Denver* after the Review was over. He consented; and after the 6th division was broken up by signal, the *Denver* came up astern of the *Minneapolis* and received an electrician whom I sent on board with two telephones. We then paid out the same spliced wire that had been used off Virginia Beach, which I had endeavored to re-enforce by seizing it at frequent intervals to a piece of signal halyard stuff. This did not work at all well; because, after the *Denver* had picked up the buoy, the seizings slipped, and the wire and halyard stuff got into

a bad tangle. The *Denver* got the wire at length, however, and we steamed ahead at 400 yards distance; but no sound could be heard through the telephones. The wire had broken again.

The trouble was clearly the mechanical weakness of the wire; and it occurred to me to see if the halyard stuff would stand the strain; arguing that, if it could, an electric wire could, provided it were as strong as the halyard stuff. So I steamed ahead at 10 knots, the *Denver* following, and there was no trouble whatever, and the piece of halyard stuff at no time had much strain on it. At the end of twenty minutes nothing had happened, and the experiment was stopped.

Now, if the *Minneapolis* and *Denver* could steam this way for twenty minutes, why could they not do it for twenty hours? And if two ships could do it, why not eight? And if they could steam this way, using a piece of signal halyard stuff, why could they not do it using a wire?

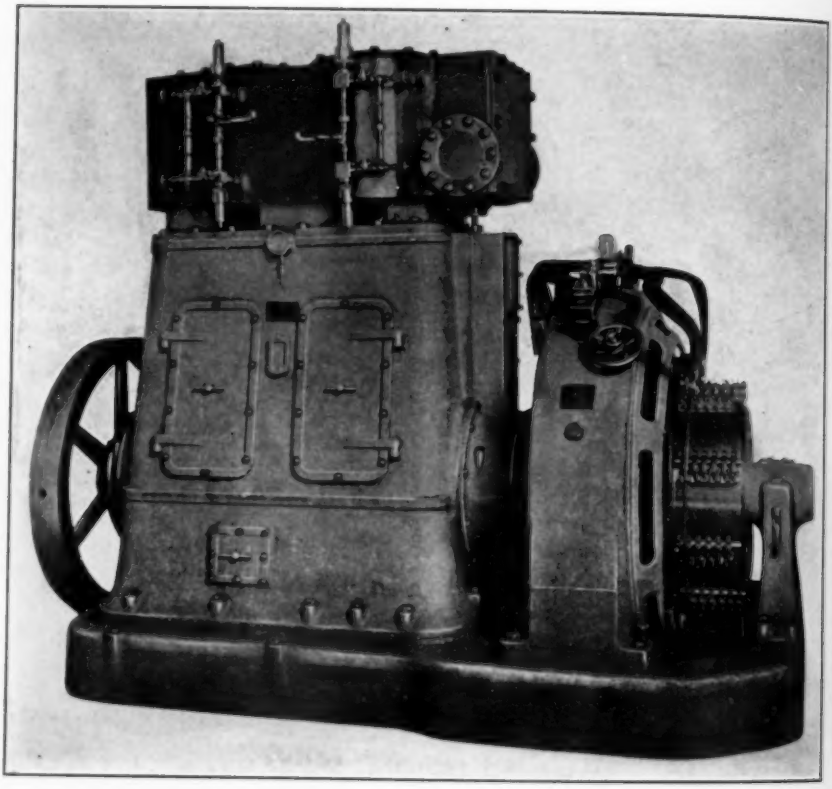
I submit this scheme simply as a suggestion. I do not advocate battleships being fitted with it, at once; and I can see that many objections may be made to it, and some difficulties met, in reducing it to practice. At the same time, it may be pointed out that many things seem impracticable at first sight, especially if they are novel, which are not impracticable at all; and which need simply a little patient experiment in overcoming "bugs" in the apparatus, and a little patient drill in using that apparatus.

It is easy—fatally easy sometimes—to condemn a new idea as "impracticable," and toss it aside; but it is harder to formulate a definite and logical objection to it. Now, what definite and logical objection can be formulated against this plan? Why should it not be tried? It can be tried very cheaply and very easily.

If we had any plan now by which ships could steam together in a fog safely, we might be very haughty in regard to suggested schemes; but we have not. No ship knows where any other ship is, or what she is doing; and if it becomes necessary to change course or speed, or if any ship gets even partially disabled, all hands are in peril, principally because of the extreme liability of misunderstanding the steam whistle signals, and the long time required to get them down the column and back to the flagship It is true that wireless telegraphy can be used for making signals in a fog; but an important despatch may be coming in just at the

time when a change of course is to be made; and furthermore, it is an accepted principle that wireless telegraphy should not be used for signalling among the vessels of a fleet, when it can be avoided, because such a use would not be practicable in war. But if the plan herein outlined can be developed, communication among the ships will be perfect, much better than by wireless: and the admiral can give orders as to changing course or speed which cannot be mistaken by his captains, or picked up or interfered with by the enemy.

One important feature may be insisted on:—that, even if some accident should occur in a fleet in a fog using this plan, and even if it should become necessary to let go the connecting wires, no harm would result, and the fleet would be just as it is now.



100 KILOWATT GENERATING SET.

GENERAL ELECTRIC COMPANY.

ELECTRICAL INSTALLATIONS OF THE UNITED STATES NAVY.—Continued.[1]

A MANUAL OF THE LATEST APPROVED MATERIAL, INCLUDING ITS USE, OPERATION, INSPECTION, CARE, AND MANAGEMENT, AND METHOD OF INSTALLATION ON BOARD SHIP.

By COMMANDER BURNS T. WALLING, U. S. Navy, and JULIUS MARTIN, E. E., Master Electrician of the Equipment Department, Navy Yard, New York.

CHAPTER V.

GENERATING SETS.

A generating set for the naval service is defined to be the combination of a compound-wound, direct-current dynamo and its operating engine; the two to be direct-connected and self-contained on the same bed-plate. Very recently two 200 k. w. sets have been purchased in which the prime mover is a turbine.

The sets are classified by sizes predicated upon the output of the dynamo in kilowatts and are further distinguished, in commercial classification, or in the manufacturer's standard machines, in types, a division that denotes some improving change in construction from other types; and also by type numbers such as type H-1, type H-2, which indicate some change in the method of construction of details for the same type: the term "form" is more common than "type" in manufacturers' lists.

The sizes, with particulars, for standard navy type generating sets, with general particulars, are contained in the following table:

Size in kilowatts.	Revolutions per minute.	Weight in pounds.	Length in inches.	Width in inches.	Height in inches.
2.5	800	560	32	20	30
5	750	1,300	50	28	40
8	550	2,500	64	34	50
16	450	5,600	78	40	60
24	400	7,300	88	48	68
32	400	10,000	101	52	78
50	400	16,000	110	60	85
100	350	22,000	125	70	95

Commercial types of generating sets are met with in service but are usually installed in naval auxiliaries and colliers only;

[1] To be continued in succeeding numbers of the PROCEEDINGS and on completion to be published in book form.

they are regarded as special sets and are not included in the standards; they are commonly of 30 k. w., 15 k. w., and 10 k. w. capacities.

Types of the General Electric Company.

The form H type designation of this company is applied to the design of sets having cross-compound, enclosed engines, and may be considered in two varieties: Form H-2, a type in which the governor is inside the enclosing frame; form H-1, having the governor assembled on the fly-wheel outside of the enclosing frame, but which is no longer manufactured. From the manufacturers' standpoint, however, the form H is divided into form H-1, form H-2, and form H-3, the notation being based mainly upon difference in pipe flanges and the method of bolting.

The form H set has been designed in connection with the specifications of 1901 and represents the latest developments of generating sets.

Form H-2, 100 k. w. Generating Set.

The 100 k. w. design of the form H-2 is shown in general arrangement in the frontispiece; a cross-section is shown in Fig. 76.

The set is rated as M. P.-10-100-350, 125 volts; that is, the generator is of the multipolar type, has 10 poles (field core and coils), has a capacity of 100 kilowatts, is designed to have a speed of 350 revolutions, and is designed to generate 125 volts at that speed.

The engine has its cranks 180 degrees apart and has a speed of 350 revolutions per minute (r. p. m.) at full load with 150 pounds normal steam pressure and 25 inches normal vacuum exhaust; it will maintain the prescribed number of revolutions on atmospheric exhaust without alteration of the tension of the governor spring.

The range of steam pressure is between the limits of 120 pounds and 180 pounds. The engine will carry 33 per cent overload for a period of two hours; this contemplates an increase of governor spring tension. Normal steam pressure should be maintained if practicable as this gives best results.

The cylinders are 10 inches (H. P.) and 18 inches (L. P.) in diameter, with a stroke of 10 inches.

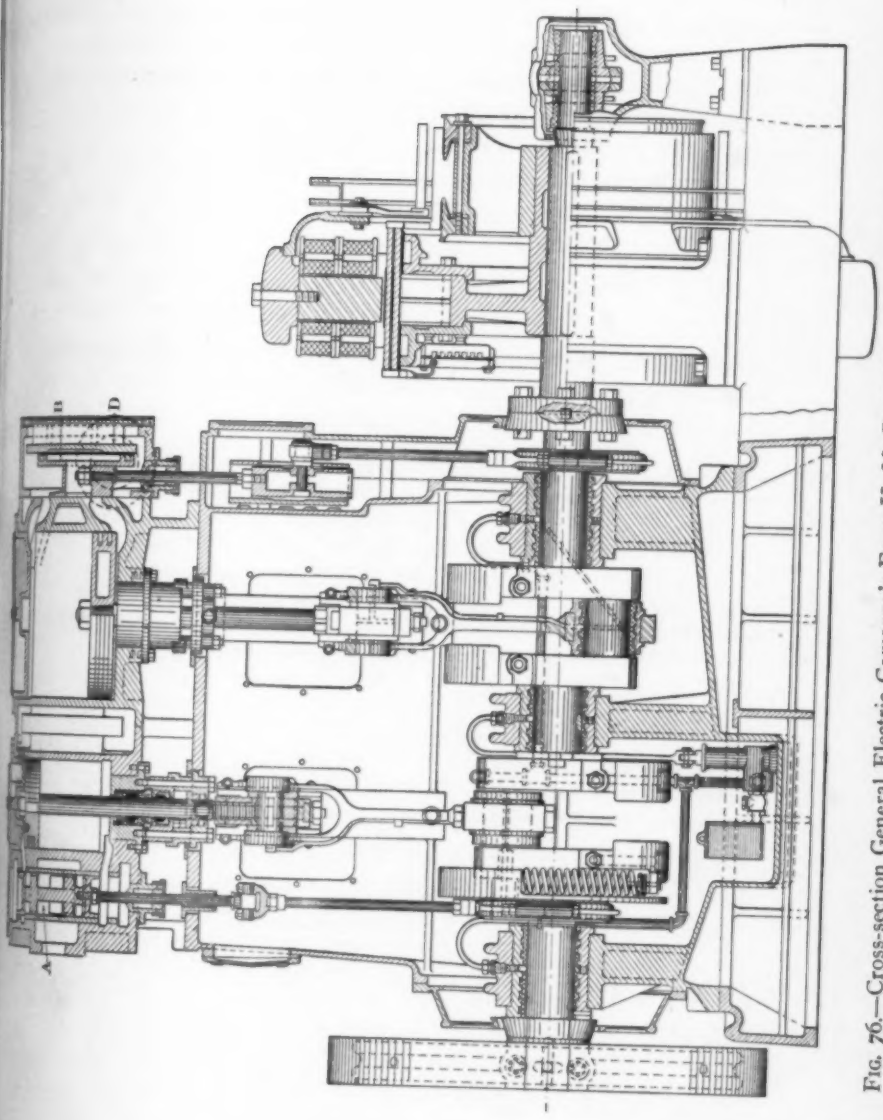


FIG. 76.—Cross-section General Electric Company's Form H, M. P. 10-100-350, 125-volt, Generating set.

The steam distribution is effected through one cast-iron balanced piston valve, *A*, Fig. 76; and one flat, partially balanced slide valve, *B*, fitted with a relief ring to reduce friction. Timed by the movement of the valve, *A*, the steam enters the high-pressure cylinder chest and valve through the throttle valve, and after doing work in the high-pressure cylinder it is exhausted to the receiver, *C*, is then admitted to the low-pressure cylinder, by the L. P. valve, *B*, and is finally exhausted through the passage, *D*, through the exhaust valve to the pipe connecting with the main exhaust pipe leading to the condenser.

The Engine.

The engine is vertical, inverted, reciprocating, cross-compound, condensing and non-condensing, double-acting, variable expansion, enclosed frame, and direct-connected.

[NOTE 9.—A vertical engine does away with any necessity for lubricating the interior of the cylinders and valve chests, and thus ensures against the entrance of oil from that source to the main boilers by way of the condenser; the lack of a cylinder lubricant may occasion wear, but this is provided for by packing rings on the pistons; in any event the renewal of a cylinder lining or cylinder itself is a small matter as compared with injury to the main boilers, which service experience shows must be protected at all practicable hazards.

The enclosed frame (casing) is found to be the best method of preventing the throwing about of oil as incurred by the requisite of forced lubrication.

The engine and dynamo are specified to be direct-connected (now almost universal commercially) as a complete bar to driving by belt, whose slipping occasions loss of overall efficiency and whose tendencies to throw off from the pulley are much enhanced by ship motions and gun shock.]

The bed-plate (Fig. 76) is an iron casting. The upper surfaces at the level of the center of the shaft are machined to take the frame, bearings for the crank shaft, the two flanges of the lower part of the field frame, and the outer bearing for the armature shaft. Between the outer and center shaft bearings the bed-plate is recessed to provide a space for the high-pressure crank, the governor operating the high-pressure valve, the oil pump, and a collecting chamber for the oil in which the pump is submerged. Between the inner and center shaft bearings the bed-plate is recessed to provide a space for the low-pressure crank; this space slants down toward the pump to assist the flow of oil.

Around the outside top edge of the bed-plate is a channel, for catching any oil or water that may escape from any of the joints or openings in the frame. In the front side of the casing are covered hand holes (frontispiece) giving access to the oil pump, the lower level of the oil chamber, for cleaning, etc.

[NOTE 10.—A combination bed-plate, upon which both engine and dynamo are mounted, forms a heavy mass initially for a foundation for both; it secures rigidity for the system and better constancy of alignment of the shaft.]

The shaft bearings (Figs. 76 and 88) are three in number, and consist of cast-iron shells, split in halves. The seats are formed by semicircular recesses machined in the bed-plate; the boxes are dovetailed for casting in a babbitt metal lining. The form of seat and the corresponding form of box admits of the

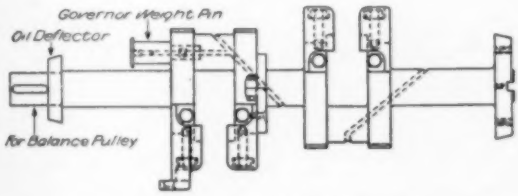


FIG. 77.—Crank shaft, M. P. 10-100-350 set.

removal of the lower half of the bearing by slightly raising the shaft and pressing down on one side of the box; the bearing will then come around to the top of the shaft in a position to be lifted off for examination or repair. The top halves of the boxes are similar to the lower halves and held in place by a cast-iron cap which is bolted to the bed-plate. Over the end bearings are hollow, cylindrical, cast-iron covers with flanges for bolting to the column. The holes in the centers through which the shaft extends, have gutters to catch the oil and prevent its dropping on the shaft.

The crank shaft (Fig. 77) is of one piece of the best forged steel with two cranks at 180 degrees, the bearings being at each side of, and between the cranks; the outer end is turned slightly smaller than the bearing and is keyed to take the fly-wheel; the inner end is flanged outwardly to form the engine half of the coupling connecting with the armature; the flange is drilled for

the coupling bolts. On the outer face of the coupling flange is a boss which matches in a similar recess of the armature flange and ensures alignment; across the face of the flange a seat is cut for a key which relieves the driving strain on the bolts; the outer surface is turned on a bevel to prevent oil from flowing over the coupling from the bearing. Holes are provided in the bearings and crank pins of the shaft for the flow of oil. Cast-iron counter weights are bolted on the cranks to assist in maintaining balance; one of these weights acts as a support for the adjusting screw of the governor spring.

The two parts of the coupling are held together by four 1¼-inch bolts, and are forced apart by two ⅝-inch set screws when it is desired to disconnect the armature.

The axial key is 1-inch square and is secured to the face of the coupling by two 5/16-inch flat-headed screws.

The shaft has a diameter of 5 inches at the bearings and 4½ inches at the fly-wheel end.

The fly-wheel (Fig. 76) is overhung on the shaft at the opposite end from the armature; it is narrow in width and extends radially well to the bottom edge of the bed-plate; the hub is split and clamped to the shaft as well as keyed. The hub extends inside of the casing of the outer crank-shaft bearing and is coned to prevent flowing out of oil. The inside of the rim is flanged inwardly on both sides to retain any oil that may be thrown out.

The enclosing frame (frontispiece) which supports the cylinders on the bed-plate, is of cast iron and has the general shape of a large tapered pipe of rectangular section; it is flanged outwardly at its lower and larger end to attach to the bed-plate, and inwardly at its upper end to attach to the cylinder and valve casting, thus forming a solid top, excepting for apertures for the piston and valve rods; this top also acts as a guard plate.

Around the sides of the enclosing frame are openings with covers affording access to the cranks, cross-heads, and valve rods (see frontispiece). On the back are four bosses, two each for supporting the cross-head slide bar.

The stuffing boxes (Figs. 76 and 78) for piston and valve rods are long and so designed that no part of the piston or valve rods which come in contact with the oil in the enclosing frame shall

enter the cylinder and valve chest, this to prevent the oil, thrown around by the forced lubricating system, from being carried up on the surface of the rods into the steam spaces and continuing thence with the steam over to the boilers. At the point of entry of the piston and valve rods through the upper end of the enclosing frame, a simple form of stuffing box is arranged which acts as a wiper.

[NOTE 11.—The precaution of a long stuffing box and a wiper has been found to be insufficient. In an experiment made on a 50 k. w. engine, to ascertain the amount of oil which actually passed into the low pressure cylinder in 24 hours, the large amount of five pints was recovered in a test oil-separator; this would mean over two gallons per day for each

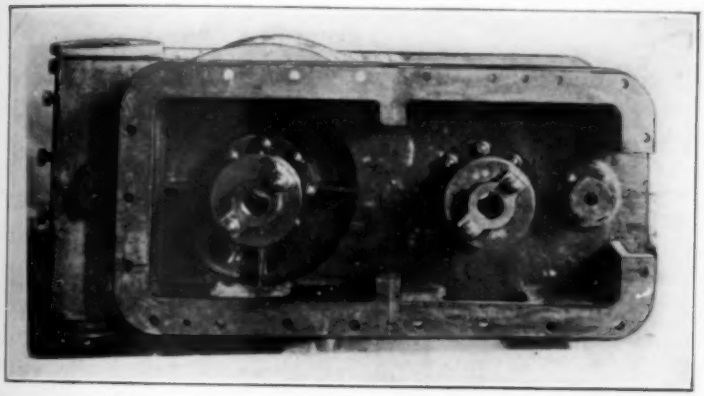


FIG. 78.—Bottom view of stuffing boxes.

100 Kilowatt machine in the ship; the result is undoubtedly due to the suction of the vacuum. For the present, to avoid the conditions, experiment is making by raising the cylinders about 10½ inches, 8 inches, and 7 inches for the 100, 50, and 32 k. w., respectively, necessitating increased length of piston and valve rods, and by improving the efficiency of the wiper; the raising is effected by a cast-iron distance piece; the alteration refers to General Electric sets.]

Rod Packings.—Ordinary soft packing of good quality is sufficient for the valve stem stuffing boxes.

The piston-rod packings are metallic and of either of two types, the United States or the Tripp.

A set of the **United States metallic packing** is shown in cross-

section in Fig. 79. In the bottom of the stuffing box is placed a cast-iron spacing ring or bushing which centralizes the steel spiral spring, *C;* this keeps a pressure on a cast-iron follower, and prevents the rings from following the rod on reversal. The follower fits the rod loosely and carries the pressure of the spring to the three anti-friction metal packing rings 1, 2, 3, contained in the cast-iron vibrating cup *A*. The bore of the vibrating cup is 1/64 inch larger than the piston-rod diameter. The composition of the anti-friction metal of which the packing rods are made is of either of the two formulæ:

Tin	87	8⅓
Copper	8	
Antimony	5	8⅓
Lead	—	83⅓
	100	100

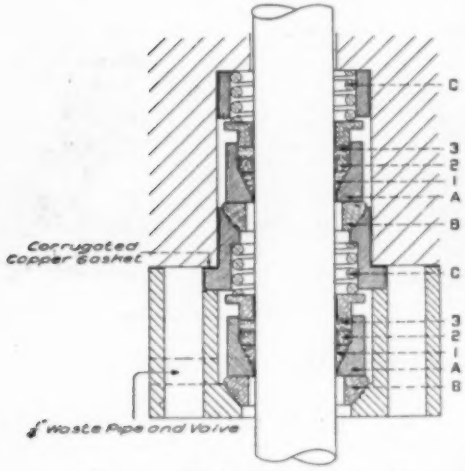


FIG. 79.—United States metallic packing.

These rings are cut in two, after being machined to shape: the "No. 1" ring usually with a separation of 1/32 inch and the "No. 2" and "No. 3" rings with a separation of ⅛ inch to ¼ inch. The joints are staggered in assembling. The lower end of the vibrating cup sets on a cast-iron ring, *B*, forming the ball joint; this joint sets in a curved seat on a cast-iron flanged ring, which forms the dividing gland. Between the gland and the cylinder heads is a copper gasket for making a steam joint.

Below the gland is a similar set consisting of a spacing ring, ring, follower, packing rings, vibrating cup, and ball joint, contained in the cast-iron recessed gland shown by the light shading; this gland is secured to the end of the cylinder by stud bolts. Above the level of the lower ball ring a ¼-inch wast pipe is tapped into the lower gland, as shown, draining off any water that may get by the upper set.

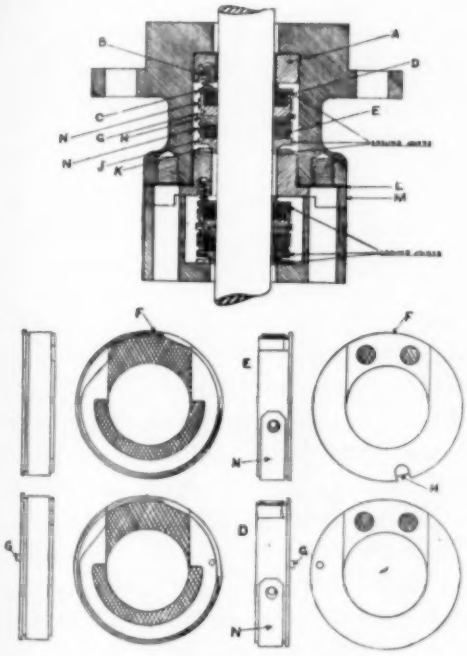


FIG. 80.—Tripp metallic packing.

The principle of the action of this packing is that the pressure of the steam acting upon the spring forces the rings "No. 1" and "No. 2," by the wedging action of their outer surfaces, against the coned surfaces of the vibrating cup and the piston rod. The spring in the upper set supplies about 10 per cent of the pressure.

The Tripp metallic packing, as usually fitted to the high-pressure piston rods of vertical, compound engines, is shown in Fig. 80. The spring case *A* is a ring of cast iron which clears the piston rod, and spaces, in holes on its lower surface, the round

steel springs *B* which hold the sets of packing in position by pressure on the cast-iron ring *C*. The packing rings, *D*, *E*, are bronze castings and are filled with a special grade of babbitt metal; these are in two parts, as shown, the babbitt being indicated by cross hatching. A pin enters the hole in the end of a flat steel spring *N*, and located at the other end of the spring with reference to the part of the packing *F*, keeping it in contact with the piston rod. Another pin in the upper ring at *G* enters the hole *H* in the lower ring forming the other element of the pair of packing rings, and locating the joints on each with reference to the staggering necessary to ensure against leakage. Below the lower packing ring is a cast-iron "ball," *J*, which engages with the cast-iron "ball ring," *K*, and provides for any vibration or faulty alignment of the piston rod; the surface between the two packing rings will admit of their sliding on each other for the same purpose. A gasket, *L*, and the gland, *M*, complete the first set of packing. The pressure of the parts of the two packing rings against the piston rods is afforded by the steam which enters the space around the ring. The lower part of the packing is similar to the upper and supplements it by acting in case of its failure and also by catching any water that may work through the upper. Such water is drained off by a pipe entering the space around the lower rings; this pipe is not connected to the regular drains as its proper operation requires no back pressure; it is led to a save-all. For low-pressure cylinders the upper set of packing is replaced by a single ring like the spring case *A*, and similarly fitted with springs at its lower side which bear against the gland *M*. The packing is put in the lower section to afford access at the same level as the high pressure.

The cylinder and high-pressure valve-chest casting (Fig. 76) is in one piece and has an extension at its lower end. It is flanged outwardly, to combine with the facility of attachment to the enclosing frame a space for access to the stuffing boxes of the piston and valve rods. The castings are of hard, close-grained cast iron, accurately bored. The lower ends are bored smaller than the full diameter required for the stuffing boxes; this necessitates removing the pistons and the high-pressure valve from the top. The cylinder bores are without liners. The seat for the high-pressure valve is fitted with a cast-iron bush which is re-

tained by being pressed into place. The casting is covered thick with best quality asbestos and lagged with planished sheet iron.

The low-pressure valve chest is separate and is bolted to the low-pressure cylinder.

The throttle valve (Fig. 81) is of the flanged, globe type; it is a 90-degree angle valve, looking upward, and of the Lunkenheimer, regrinding type; the diameter is 3½ inches. It is attached to the casting at the fly-wheel end and can be reached by pipe from either direction. The valve is fitted with a ½-inch by-pass, integral with the body. The valve stem is carried outside of the valve through the yoke; a bolt and gland stuffing box is used.

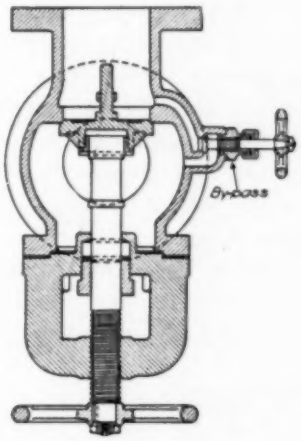


FIG. 81.—Throttle valve.

[NOTE 12.—To regrind the valve seat when worn or leaky. If the main valve, unbolt the bonnet, take the nut from the end of the stem, and remove the hand wheel, after which remove the entire trimming from the valve body. The stem can then be unscrewed and drawn from the yoke. Prepare some abrasive material, such as a little powdered glass, sand, or carborundum, mix it with oil, and apply this to the disc. Make the disc rigid with the stem by inserting a nail or a piece of wire through the drilled hole below the lock-nut. The valve can then be reground by fastening the hand wheel to the stem, the extension of the disc being guided by a bridge in the body of the valve, which will enable the new seat bearing to be reground in perfect alignment. When the valve is reground wipe off all the abrasive material from the seating surface and remove the wire pin from the disc.

The by-pass is not provided with a grinding-in guide; it can be reground with the same abrasive.

All other valves on this engine are of the union bonnet construction; it is unnecessary to remove the stem from the valve trimming, as the hub of the trimming should guide the body and keep the stem in line with the seat, otherwise the regrinding is effected as above.]

The exhaust valve can be attached to the extreme end of either side and be reached by pipe from either direction. This valve is also of the Lunkenheimer type.

The heads for the top of the high-pressure cylinder and high-pressure steam chest are combined in one and are finished off by a polished, light, iron hood casting.

The head for the low-pressure cylinder is separate, and is also finished off with a polished hood.

The high-pressure and low-pressure cylinder heads are fastened to their respective cylinders by twelve ⅞-inch studs and nuts; the flanges of both heads and low-pressure steam chest cover are tapped for two ¾-inch eye-bolts for lifting off.

The cover of the low-pressure valve chest is a flat casting heavily ribbed at the outside.

The high-pressure valve (Fig. 76) is of the solid piston type, single-ported, variable travel, and balanced by being surrounded by steam; it takes steam at the center between the heads. There is no adjustment for leakage except by turning down and replacing the valve-chest bush, as the valves are solid. The steam lap is ⅞ inch top and bottom; the exhaust lap, top and bottom, is zero. The travel of this valve is controlled by the automatic governor, and varies between 3¾ inches and 1⅝ inches. The cut-off varies between ¾ inch and zero, depending on the load.

The low-pressure valve (Fig. 76) is of the flat, single-ported, constant-travel type, balanced by an annular surface on the back in which is fitted a ring which is pressed out by springs against a bearing surface on the side of the steam chest cover; it takes steam at the inside and exhausts at the ends. The steam lap is 1¼ inches; the exhaust lap, top and bottom, is zero. The valve travel is 3¾ inches, giving a cut-off of about half stroke.

The high-pressure piston is shown in Fig. 82. It is a cast-iron disc containing two rectangular grooves, which receive the packing rings of the type as shown in the figure. The piston is taper-bored to take the rod, as shown, fitting against a shoulder

on the piston rod, and is secured to the rod by a nut on its upper side; the outer face of this nut contains radial grooves, one of which engages a split pin which prevents the nut from unscrewing. The **low-pressure piston** is also of cast iron, the general construction being the same as that for the high pressure, excepting that the piston is cored instead of being solid. The **piston packing,** or packing rings, as shown, consist of cast-iron arcs, three sections for those used on the high-pressure piston and four for those used on the low pressure. The arcs overlap at the ends and are made steam tight by brass tongues, one of which is riveted to each arc. The packing is held tightly against the cylinder wall by flat springs 3/8-inch wide and 1/16-inch thick, secured to the arcs by machine screws.

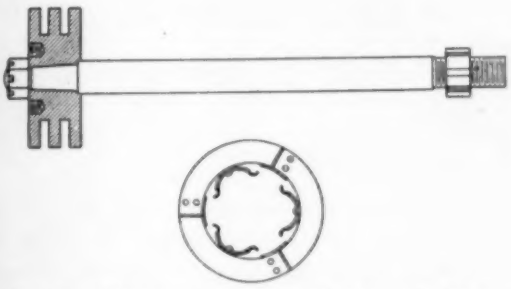


FIG. 82.—Piston, piston rod, and piston packing.

The piston rods (Fig. 82) are of nickel steel, and are threaded to a less diameter than the body of the rod at the lower end where they screw into the cross-head and are locked by a jam nut. The threading into the cross-head affords a convenient means of adjustment of the piston clearance at both ends of the stroke. The diameter of both the high and low-pressure rods is 2¼ inches.

The cross-head (Fig. 83) is a mild steel forging. The cross-head shoe, *B*, is of composition metal, babbitted, and has a liberal wearing surface, that the wear may be reduced. The shoe is secured to the cross-head by two 1-inch bolts and is held against the guide bar by the clamp, *C*, which is secured to the shoe by six through bolts, the proper distance between the shoe and the clamps being adjusted by liners, *D*. The cross-head is slotted to receive the wrist pin bearing, *E*, which is made of gun metal, and held in place by the cap, *F*, and two bolts secured by the lock-

nuts, *G*. The upper part of each nut is turned circular and fits in a recess in the cap; set screws, *H*, prevent the nuts from turning, and set screws, *J*, prevent the turning of the bolts. Wear is taken up by filing the edges of the brasses, and, on account of the system of oiling which is used in this engine, it is important that

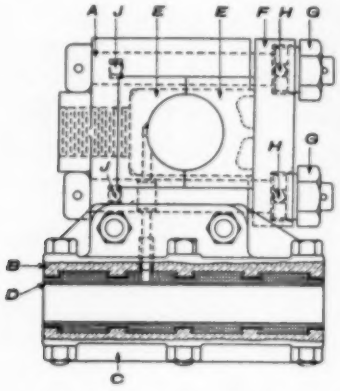


FIG. 83.—Cross-head.

these edges should always be together. The bearing should be so adjusted that, when the brasses are hard together, the wrist pin will move freely but without play. Oil reaches the bearing from the oil pipe, *G* (see cut of connecting rod), passing up the side of the connecting rod; from this bearing the oil is forced further to the guide.

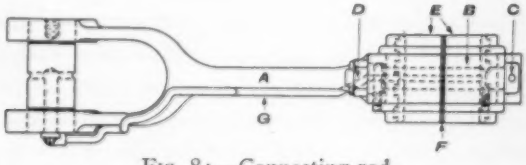


FIG. 84.—Connecting rod.

The connecting rod (Fig. 84) consists of a forged steel body, *A*, forked at its upper end to receive the wrist pin, which is shrunk into the connecting rod. The lower end of the rod terminates in a stub, to which the crank-pin box is secured by a steel cap, *B*, and two 1-inch forged steel bolts, *C*, held by lock nuts, *D*. Split pins pass through the ends of these bolts, preventing the lock nuts from coming off.

The crank box, or **crank-pin bearing** (Fig. 84), is a hollow, cylindrical, cast-steel shell, *E*, split in halves. The shell has two small flanges which fit the connecting rod and prevent the shell from moving sideways; it is prevented from turning by through bolts which make a guide for it. The inner surface of the shell, which comes in contact with the shaft is babbitted and wear is taken up by removing the fiber liners, *F*.

As the oil must be forced from this bearing up to the wrist pin and cross-head guide, it is important that the boxes are always tight together or there is likelihood of leakage of the oil.

The wrist pin, or **cross-head pin** (Fig. 84), is of machine steel, case-hardened and ground; a small groove is cut at the two points where it joins the inside of the fork of the connecting rod.

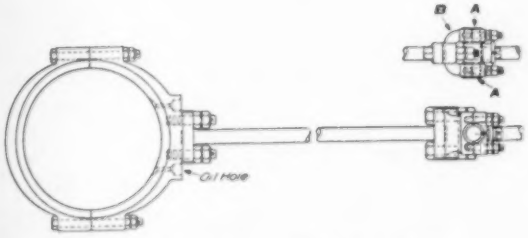


FIG. 85.—H. P. eccentric rod and strap.

It is bored at one end for an oil way to the center of its length; at this point it meets a through, vertical cross-bore which admits the oil to each half box.

The high-pressure eccentric is an iron casting which is split to embrace the shaft; it swings in an arc whose center is a bearing pin of machine steel, cases-hardened and ground and pressed into the side of the high-pressure crank. The governor weight is cast solid with the high-pressure eccentric.

The low-pressure eccentric is an iron casting, split to embrace the shaft, and secured to it by two set screws.

The high-pressure eccentric rod and strap, with forked brasses, which are in three pieces, are shown in Fig. 85; the rod is round steel. These brasses are secured to the upper end of the eccentric rod, and the lower end of the rod to the top half of the strap, by two ¾-inch studs. The halves of the strap are separated by liners, for removal for adjustment for wear.

The bearing caps, *A*, are each secured by studs and double nuts, fitting brass and brass, wear being taken up by filing the cap faces.

The low-pressure eccentric rod and strap are of the same general construction as explained for the high-pressure rod and strap with the exception that the brasses are in two pieces instead of three.

The guide for the high-pressure valve stem is of cast iron; it is bolted to the engine column, and is fitted with a composition metal bushing which is pressed into the guide.

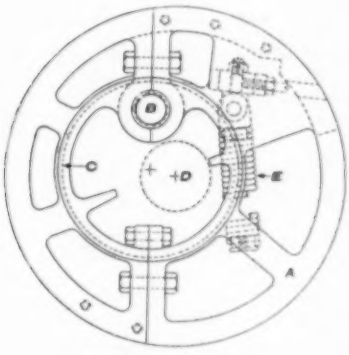


FIG. 86.—Governor.

The valve rods, or **valve stems,** are of steel, larger in the center when in contact with the two stuffing boxes, and reduced at each end.

The upper end of the **high-pressure valve rod** is screwed into the body of the valve and secured by a lock nut; the upper end of the **low-pressure valve rod** passes through the valve and is secured by double ⅞-inch nuts on the upper side. These nuts should be locked hard together, *but the stem should be free to turn in the valve,* though without any play. The rod is fitted with a taper washer which permits the valve to adjust itself on the stem.

The valve rods are threaded at their lower ends and secured by lock nuts. The **high-pressure rod** is screwed into the small cross-head (Fig. 85). The central portion of this cross-head is square with cylindrical ends, forming a bearing with the forked link, *B* (Fig. 85), which is bolted to the upper end of the eccentric rod. The **low-pressure rod** is screwed into the body of the

valve rod slide which has a bearing in the cast-iron guide bolted to the engine column.

The governor is of the Rites dumb-bell type, modified to suit the conditions occasioned by the swinging eccentric and the limited diameter which is available inside the frame and bed-plate. (See notes on generating sets for description of the Rites design.)

The governor is shown in Fig. 86, and consists of a single fly-weight, *A*, in halves, which are securely bolted together and pivoted, at *B*, to the main bearing pin, which is driven into the crank and secured by a set screw as shown in the illustration of the crank shaft (Fig. 77). The fly-weight is supplied with a loose brass bushing, which provides a double bearing surface. The pin and bushing communicate with the inside of the engine and are, therefore, always under an oil pressure which minimizes the chances of sticking or binding.

[NOTE 13.—This matter of good lubrication is the great advantage of an inside governor, out-weighing by assurance of good working the convenience of being more accessible when outside of the casing.]

The operation of the governor is as follows:

The eccentric rod and strap (Fig. 85) which transmit motion from the governor to the high-pressure valve, are connected to the eccentric, *C*, which forms a part of the fly-weight casting. It is evident that the length of the valve stroke (travel of the valve) depends upon the distance of the center of the eccentric, *C*, from the center of the shaft, *D*. The amount of steam which will be admitted to the cylinder by the valve will, then, vary directly as the distance between the centers for *C* and *D;* that is, the less the distance between those centers, the less the amount of the valve travel and the less the amount of steam admitted, and *vice versa.*

Suppose now that the dynamo is suddenly relieved of some large amount of current supply, thus relieving the engine of an important amount of its load, the engine would immediately tend to speed up under the existing head of steam; this speeding up would cause the fly-weight, *A*, to be immediately thrown out by centrifugal force from the shaft, thus decreasing the distance between the centers of *C* and *D*, the length of travel of the valve would be thereby decreased, less steam would be admitted to the cylinder, and, the head of steam being decreased, the engine must

slow down; that is, the tendency of the engine to speed up has been counteracted. It should be especially noted that, the greater the tendency to speed up, the more the distance between the centers between *C* and *D* will be decreased until this distance is reduced to its practicable minimum (not quite coincidence, however) when the valve will practically close the ports and admit almost no steam at all. This action, therefore, protects the engine against dangerous racing.

The outward swing of the weight under centrifugal force is controlled by the heavy coil spring, *E*, which is attached to a bracket cast with the crank-shaft counterbalance; this provides a method of regulating the speed to that for which the engine (actually the dynamo) is designed to run. By *increasing the tension of the spring* the tendency of the outward swing of the weight is resisted, the travel of the valve is less readily decreased, and the effect is to *increase the speed;* from similar reasoning a *decrease of the tension of the spring* will *lower the speed;* the same effect will be produced by moving the spring in the slot provided for it in the weight—moving the spring *away from the fulcrum* increases the speed, and moving towards the center produces the opposite effect.

[NOTE 14.—Although unstable regulation of speed is due principally to too close an adjustment of speed, and may be remedied by moving the spring attachment *away* from the fulcrum, the process requires skill and care; it is the experience of those handling the Rites design of governor that, where the regulation remains unstable after careful adjustments by the spring, it is a difficult matter to obtain the exact point of relation between spring and fulcrum adjustment when their effects are combined; that is, fulcrum adjustment requires long practice. It is common practice for engine builders, lessees under the Rites patent, to submit the question of a design for a governor of the particular size and type to the experts of the Rites corporation and obtain all details of construction and adjustments from them; this does not necessarily assure the success of the governor without assistance of experts. **Fulcrum alterations should not be permitted aboard ship.**]

Relief valves are attached to each end of each cylinder and in connection with the drains (Fig. 87). The valve is held to its seat by a spring adjustment made through the set screw at the top, which is tapped through the head and fastened by a jam nut; the set screw bears down upon a spring head (see also drainage system below).

The drainage system is shown in Fig. 87, in which the connections, the 1-inch relief valve, swinging check valves, and three-way indicator cock are for the high-pressure cylinder (see also frontispiece). The 1½-inch relief valves for the low-pressure cylinder are of the same general construction.

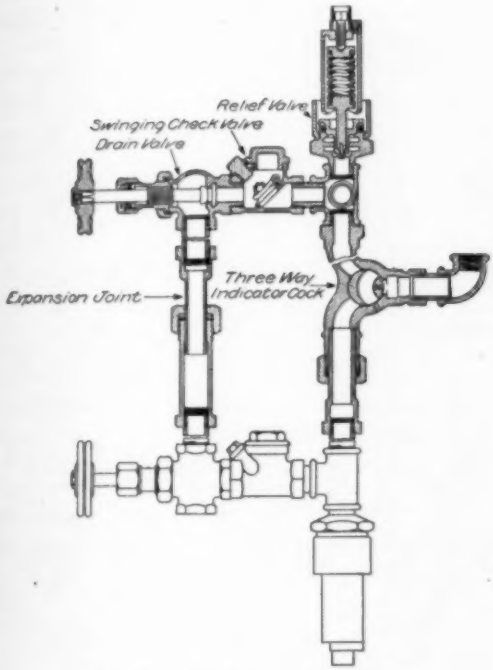


FIG. 87.—Drainage arrangement.

Indicator Motion.—When a card from the engine is desired, a small cover (see frontispiece) must be removed from the front of the engine column, exposing a slot over which a bracket containing a bearing pin for the levers is attached. Each cylinder has its individual indicator motion consisting of a stud for driving the motion and which is screwed into the wrist pin of the connecting rod, this connects through a link to a lever pivoted to the bracket covering the slot in the column. The motion for the indicator barrel is taken from the card pin on this lever.

The Forced Lubrication System.—The lubricant is carried under pressure to the various part of the engine by the mechan-

ism shown in Fig. 88. The bed-plate of the engine forms an oil reservoir (Fig. 76) to which is attached a small plunger pump, driven by an eccentric on the shaft, and receiving oil from the reservoir in the bed-plate through a strainer (Fig. 76). The oil is forced by this pump to grooves in the main bearings (Fig. 88), and drilled holes connect these grooves with the crank pins, the oil being further forced to the wrist pins through the pipes on the side of the connecting rods (Fig. 84).

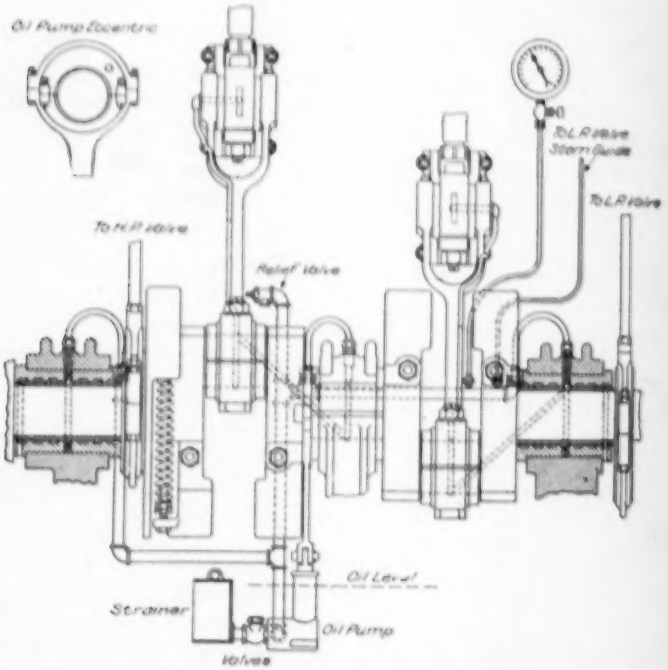


FIG. 88.—Forced lubrication system.

The passages in the cross-heads (Fig. 83) permit forcing the oil from the wrist pins to the guides, as shown.

A pressure gauge is attached to the system to indicate the oil pressure delivered by the pumps. The best working pressure is from 10 to 20 pounds and is made adjustable by the relief valve (Fig. 88) which is provided with an adjusting set screw at the back of the engine where the valve projects through the engine casing.

The oil in the reservoir should stand about 3½ inches over the suction and discharge valves and be freed of water by running through the oil filter.

[NOTE 15.—The forced lubrication system for high speed engines is now recognized as a great improvement on methods of gravity sight feed lubrication in preventing hot bearings, reducing wear to a minimum, and minimizing attention.

It is important that the oil be free from all substances such as particles of waste or grit; and, to guard against the introduction of any foreign matter, a strainer is attached to the suction valve of the pump, which may be taken out for examination or cleaning at any time whether the engine is in operation or not.

It is not necessary, nor desirable, to keep the pressure gauge in circuit continuously; it is intended more as an instrument for testing the pressure from time to time.

Only mineral oil should be used for lubrication; that which has stood the test for even small machines and over a range of years is Arctic Engine Oil. As the oil passes through the bearings repeatedly, it gradually loses its lubricating qualities, becoming thick and gritty and mixed with water, and should be run through a filter and mixed with new oil; the frequency of this change depends upon the oil as well as the number of hours the engine is in operation; it can be determined by observation for the particular case and ship, and should be part of the established routine of every dynamo room.

The oil level in the reservoir must not be high enough to permit the cranks or counterbalance weights to strike in the oil; the oil thrown about within the engine casing from leaks under pressure is rather more than is desirable as it is; the lubrication is amply sufficient as designed and splashing the oil by fast turning cranks and weights only causes foaming and heating. A good rule is to have the oil level from 1½ to 2 inches below the lowest plane reached by the crank or counterbalance.]

The Generator.

All the generators of the General Electric Company's manufacture have an armature of the slotted core, barrel-wound type, in sizes below 100 k. w., the armature is usually series-wound; that for the 100 k. w. is multiple (or parallel) wound. The 100 k. w. has ten or eight poles; the 50 k. w. of the form H design, eight poles; the 50 k. w. of the tandem-compound set, six poles; the 200 k. w. turbo-generator has four poles and four inter-poles.

[NOTE 16.—The slotted-core construction is now very general; its main advantages over the "smooth body" armature—in which insulated wires

are wound round the armature core ring (Gramme ring winding)—are: *first*, superior induction, the slotted core designs developing in the teeth about 116,000 lines of force per square inch and 92,000 in the magnet core as compared with 80,000 to 85,000 in the best designs for the Gramme ring; *second*, better mechanical construction, inasmuch as the armature circuits are sunk in the slots and wedged in by the top-sticks, the whole being held firmly by the binding wires; the conductors on the periphery of the armature are thus removed from danger of mechanical injury, a menace in the smooth-body assembly, if the shaft be out of line by bringing the periphery of the armature too near the pole pieces, the periphery of a slotted-core armature is the metallic edge of its core discs, the conductors being farther protected by the top-sticks; *third*, the gap space, or radial distance from the pole piece to the conductors can be lessened, thus decreasing resistance in the magnetic circuit and strengthening the magnetic flux, and at the same time the net radial distance from the periphery to the pole pieces is increased, giving better mechanical clearance; *fourth*, the conductors are protected from the injury of the heavy torque in case of short-circuiting of the armature winding.

The selection as to series winding or multiple winding in an armature for ship use is mainly a question of reaction, that is, output. In the larger sizes of these direct-current generators the multiple winding is practically a necessity for the reason that there are no features in the two-circuit (series) windings which tend to subdivide the current equally between the different brushes of the same sign. Consequently, if there is any difference in contact resistance between the different sets of brushes, or if the brushes are not set with the proper lead with respect to each other, there will be an unequal division of the current and excessive heating of the windings. For example, suppose two conductors to be paralleled, each having a resistance of one ohm and each carrying a current of 100 amperes, the heating effect in each will be 10,000 watts, or, for both, 20,000 watts ($200^2 \times \frac{1}{2}$), but if from unequal contact, one carries 120 amperes and the other 80, the heating will be $14{,}400 + 6{,}400 = 20{,}800$ watts; hence the effect of unequal division of the current in the two paths increases the total heating effect and materially increases the heating of that path which carries the excess current. When there are as many sets of brushes as poles, the magnetic density at each pole must be the same, otherwise the position of the different sets of brushes must be shifted *with respect to each other* to correspond to the different intensities. In practice it is found difficult to prevent the shifting of the current from one set of brushes to another; the possible excess of current at any one set of brushes increases with the number of sets, likewise the possibility of excessive sparking, and for this reason the statement has been sometimes made that the disadvantages of the two-circuit windings increase with the number of poles. In the case of multiple windings, the drop in any circuit, as well as the armature reaction in the field in which the current is generated, tends to prevent the excessive flow of current from the corresponding set

of brushes. The principal advantage of the multiple-drum winding over the series-drum is the relatively lower voltage per bar, which becomes very important in large direct-current generators; as a comparison consider an 8-pole 300 k. w., 100 r. p. m., generator generating 550 volts, details would be:

	Multiple-drum.	Series-drum.
No. of slots	272	204
Conductors per slot	6	2
No. of commutator bars..	816	204
Volts per bar	5.6	22.5

An 8-pole series-drum winding, therefore, requires but one-fourth the face conductors of the multiple-drum; it being necessary in the design of the example cited to reduce the number of commutator bars to 204, the voltage per bar, if wound series-drum, would be prohibitive.

The multipolar construction has several advantages over the bipolar:

I. Stray field, from the poles, is minimized, a consideration in ship use.

II. The total permissible current is divided up into a convenient number of k. w. per magnetic circuit, permitting large outputs. (It is convenient in this connection to look at a multipolar construction as so many machines in parallel per pair of poles; that is, an 8-pole machine would be regarded as four separate machines in parallel; this convenient method is not, however, strictly applicable.)

III. The areas for radiation of heat from the armature, commutator and field coils are increased, permitting the material to be worked to greater activity.

IV. The magnetic circuits are shorter, requiring less weight of copper and magnetic metal.

V. Less space is required.

As regards the number of poles a generator is to have, a simple, rough rule for other than very large machines or especial cases, is to allow a current density of 100 amperes per set of brushes, or per pole; this determines the number of poles as being the quotient of the total full load current divided by 100, the next higher even number being used. This would assign the number of poles, neglecting the requirement for 33 per cent overload, at 125 volts, as follows: 100 k. w., 8 poles; 50 k. w., 4 poles, and lower sizes at 4 poles arbitrarily, in order to be multipolar, with probably but two sets of brushes for 24 k. w. and less. A large number of poles tends to reduce the tendency to sparking, but it adds to the size of the generator and hence to the weight. The 100 k. w. machines now have 8 poles, though the first made were designed for 10 poles. The 50 k. w. machine has 6 poles instead of the 4 calculated; but the machine is really a 75 k. w. machine on commercial rating of a heat rise of 40° C. in the armature, and for 75 k. w., 600 amperes are required at 125 volts; hence, for 6 poles the rule is verified in this case also.]

The generator develops 800 amperes at 125 volts normal rating, but is capable of carrying 1067 amperes at that voltage for two hours. It is shown in cross-section in Fig. 89 and is separable in description into two distinct parts: *The field assembly*

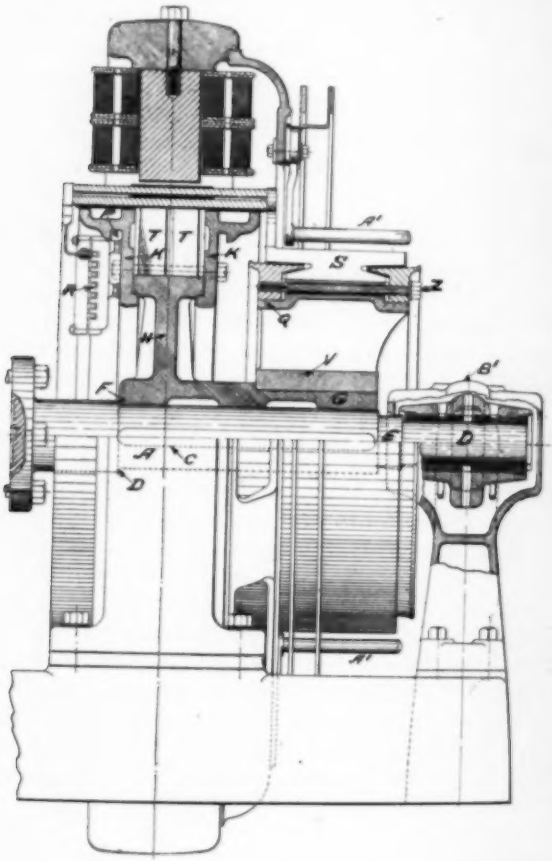


FIG. 89.—Cross-section 100 k. w. generator.

(including the frame, poles, or field magnets and carrier, or rocker) and the *armature;* these two parts are also the two electrical divisions as the frame is a part of the magnetic system of the field cores.

The Field Assembly.

The frame (frontispiece) is circular and is a two-piece casting. It is extended down on each side to form feet cast in one with the lower half of the frame; the two halves of the frame are connected together by two bolts on each side which are not visible, being entered through pockets in the bracketing of the feet; this pocket is covered by a sheet-metal cap. The base of the feet are planed to rest on a liner on the planed surface of the bed-plate, and to this the feet are secured by two bolts through liner and bed-plate; the upper half is similar to the lower with feet omitted.

The carrier (frontispiece) is a circular casting with lightening holes, which fits into a guide recess on the commutator side of the frame and is prevented from moving out of the recess by the cylindrical end of ⅜-inch filister head cap screws, which engage

FIG. 90.—Connecting lug and wire connector.

in a groove in the frame; on the upper inner side a toothed segment is fitted, which engages the pinion of a shaft extending through the frame; this shaft is operated by a hand wheel to vary the lead of the brushes on the commutator within required limits. The two collector arcs for opposite polarity are rigidly secured to the carrier as are also the 10 studs for the 10 sets of brushholders. The brush leads for the total armature current are connected to the collector arcs and are led loose to two hard rubber blocks or boards, secured over and near the top of the frame (Fig. 91). One block carries the connections for the positive brush and line leads and the leads to the rheostat; the other carries the negative brush and line leads and the lead for the equalizer; it has also a connection for the return from the rheostat, if desired to connect short shunt; on board ship, however, the negative from the rheostat is connected at the switchboard, or by long shunt.

All the leads connecting to the boards and collector arcs have their ends soldered into a connecting lug (*A*, Fig. 90), which can

be securely bolted by copper bolts; this assures good electrical contact in each case.

The generator name plate is usually placed on the frame; the armature number is on the end of the shaft.

The poles, a section of one of which is shown in Fig. 89, consist of a core, a series-winding, and a shunt-winding. The whole assembly is secured to the frame by a single bolt, which is tapped into the center of the core, thus permitting the backing out of the bolt, and removal of a complete pole assembly without removing the armature.

The core is a cylinder of soft cast steel, turned to fit against the interior surface of the bored frame; and, at the armature end, concentrically with the radial distance from the center line of the armature shaft. The pole pieces, or shoes, are cast solid with the cores.

The field windings, series and shunt, are separately wound on spools; the spools are slipped on over the cores before the cores are placed and are held in place by the projecting shoes; the shunt winding spool goes on first, next to the frame. In each spool an annular space is left in the center of the winding (Fig. 89) for ventilation.

The Series Coil.—The *series winding* consists of 6½ turns per coil of strip copper 2¾ inches by .075 inch, arranged five in multiple. The weight per coil is approximately 58 pounds; the cold resistance is .000118 ohm.

The coil is wound on a form. Before beginning the winding .14 inch of pressed board is placed around the form to allow for wrapping space. The "I" ("inside") series lead is first soldered on and insulated with a wrapping of five thicknesses (turns) of varnished cambric, each turn being coated with shellac to hold the turns together; beneath the "I" lead are placed two thicknesses of varnished cambric to prevent the rivet heads from working through the insulation on the bottom of the coil. The winding is then begun, a piece of .03-inch leatheroid being placed between the "I" lead connection and the first turn of the copper. The first two turns of copper are insulated with one thickness of .008 muslin of sufficient width to lap over the top of the form; the coil is then clamped, removed from the form, and insulated by wrapping around it two layers of varnished cambric, lapped

one-half. A piece of 8-ounce duck is next sewed on under the "I" lead, of sufficient length to extend to the top of the second turn of copper, under which the coil is wrapped with one thickness of 1-inch stay-binding, lapped one-half. The coil is then replaced on the form and wound with two turns of bare copper; between these turns are placed the space blocks to form the annular ventilating space, and of such thickness as will round out the coil. The winding is then resumed, the .008-inch muslin insulation being placed between the turns. Before cutting the copper used in the winding, the "O" ("outside") lead is riveted and soldered on, and is insulated in the same manner as the "I" lead. After this, there are placed under the last turn six lots, four cords each, of No. 7 boot thread, equally spaced, and extending about 12 inches beyond each side of the copper.

Four of the copper strips are then cut off, the remaining strip is neatly covered with No. 2 cotton drill and is wound completely around the coil when it is riveted to the coil beneath it and cut off; the coil is then removed from the form. Veneer collars are fitted to the coil and holes are drilled through them at the points at which the six lots of cord are located. The collars are then tied tightly to the coil by the cord, after which a lacing of cord, consisting of three turns, is placed around each arm in the ventilating space and is tied and cut off. The coil is dipped in air-drying japan before being assembled on the field core.

The Shunt Coil.—The *shunt winding* consists of 585 turns of No. 10 B. & S. G. single-cotton-covered wire. The weight per coil is approximately 72 pounds; the cold resistance is .78 ohm.

The coil is wound on a form. On the form are placed two thicknesses of No. 2 cotton drill of such width as to cover the body of the form and extend 3½ inches up each side. The portion extending up the side of the form is cut into small tongues of approximately ¾-inch width; the tongues of the two layers are staggered. To the drill is added on thickness of varnished cambric and one thickness of oiled asbestos. Four layers of wire are then wound on the form and the tongues of the upper layer of the cotton drill are turned down over the winding. The winding is then continued until the ventilating space is reached, when the tongues of the first thickness of cotton drill are turned down and the winding is completed to within two layers of the top of the

coil. At this point, pieces of cord are placed on the coil as described for the series coil, after which the winding is completed; the terminals are then soldered on and the coil removed from the form. The coil is dipped in air-drying japan before being assembled on the field core.

When the poles are assembled on the frame the series coil of each pole is connected to that of the next pole by bolting together the copper strips leading out from the series winding; the shunt

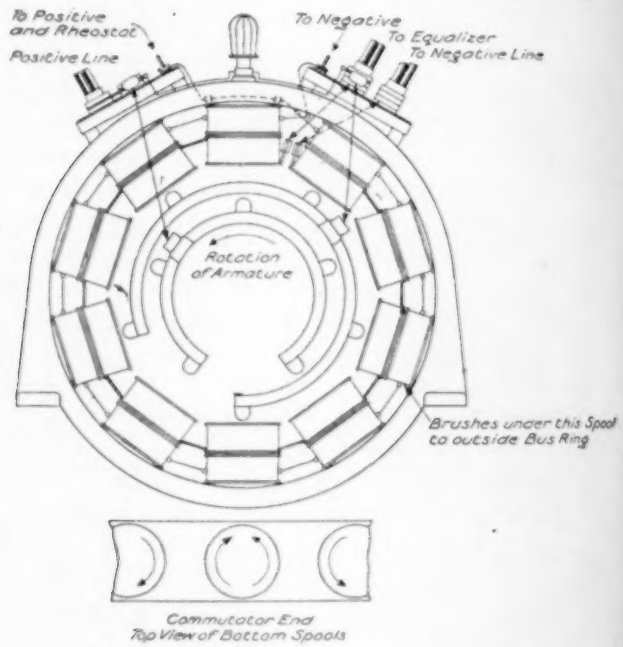


FIG. 91.—Generator connections.

wires are connected together, pole to pole, by small cylindrical connectors (*B*, Fig. 90) bored to take the wires, which are secured in the connector by machine screws. The arrangement of the connections is shown in Fig. 91.

The series shunt is connected in the gap of the series connections shown below and to the left of the negative board; it is then brought up and back of the frame. It is made of German silver resistance ribbon and, after the resistance is adjusted, is fitted with terminals for bolting in the gap.

[NOTE 17.—The action of the series shunt is more readily explained in the effect of the field winding as a whole on the terminal voltage of the generator's armature. In (Fig. 92), since the armature, due to the shunt winding, will generate its full voltage, at rated speed, before any current circulates in the line, all curves will start at *A*. Were the armature to continue to operate under its shunt conditions alone, the terminal voltage would drop as the current increased producing a curve similar to *AC*. The straight line *AB* would be the theoretical condition for constant potential, but in view of the fact that even compound machines tend to somewhat decrease in potential as the load increases, the curve *AD* is what is practically desired. To obtain the curve *AD*, by the increments *ab*, *cd*, is the office of the series field and these increments will increase in value, from the point *A* to the designed limit of load, proportionately to the increase of current. The combination of shunt and series field thus keeps the voltage constant and causes the generator to be self-regulating.

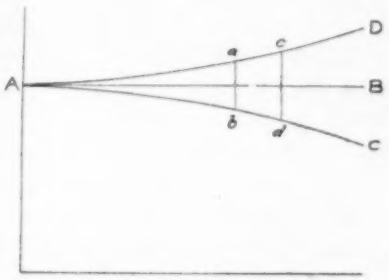


FIG. 92.—Diagram of characteristic of a compound-wound dynamo.

It is not practicable to mechanically adjust the exact resistances of the shunt and series windings to the nicety essential to the case, and two methods of field regulations are adopted: *the first* is, the introduction of a practically constant resistance shunted across the series field, which will steady the voltage under normal heated conditions of the armature and field windings at any load; *the second* is, from considerations of economy and efficiency, to reduce the field current by inserting a rheostat in series with the field winding which will cut down the voltage at the field terminals to the voltage required, and to so design the rheostat that a part of its resistance may be adjustable and thus afford a means of compensating for irregularities of speed, temperature, etc., when the generator is in operation.

The series shunt is therefore intended to be a fixed nonadjustable resistance shunted across the series winding which will assure that those increments of voltage which are added by the series field to the voltage produced by the shunt field will keep the terminal voltage within the permissible variation at any stage of load. The shunt rheostat affords in its adjustable resistance all necessary means of keeping the terminal voltage to its rated value under operating conditions.]

The Armature.

The principal parts of the armature are the **shaft**, the **spider**, the **armature core**, the **commutator**, the **armature winding**, and the **brush assembly**, including the connector arcs attached to the carrier.

The armature shaft (Fig. 89, *A*) is of steel and turned down its whole length except at the engine end where the flange for the coupling is forged in one with the shaft; the flange is slotted to take the radial driving key. The shaft is turned ½ inch larger, *D* (to 5½ inches), next the coupling, which affords a shoulder for the spider, *F*. The center portion of the shaft is of the same diameter as the crank shaft, 5 inches; this portion takes the spider and is fitted, *C*, with a key-way for a driving feather; the right-hand end, *D*, is 4½ inches in diameter, and is for the bearing of the self-oiling sleeve, or ring-oiler bearing. Intermediate between the bearing and the spider is an enlarged taper-turned portion, *E*, designed to prevent oil from flowing toward the armature from the bearing surface of the ring oiler.

The spider, *F*, is of cast iron with three bearing surfaces on the shaft. The hub of the spider is elongated at *G* to take the commutator; this device also reduces the possibility of any flexure of the connections between the windings and the commutator. From the hub of the spider six legs, *H*, extend to the inner surface of the armature core; in one of these legs is placed a key-way for a feather (not shown), which drives the core disc positively. The legs are joined together by two cast-iron rings, *K*, which extend up to the line of the slots and are flanged outwardly at the top to support the extension of the windings which project beyond the slots, and inwardly at the bottom to secure under the T-shaped section top of the spider leg. These rings, *K*, are drawn together by bolts against space blocks bearing on the armature core discs, and thus draw the core discs together. The ring, *K*, on the back of the armature is provided with an annular recess, *P*, to retain any oil that may crawl along the shaft from the engine bearing.

The armature core, of a total length of 4⅞ inches, is made up of two sections, or discs, *T*, which are separated from each other and from the rings, *K*, by space blocks, the interior spaces thus formed affording a system of three ventilation ducts through

the core; these space blocks, are metal castings, consisting of a ring on which are placed radial arms carrying the actual blocks and fitted over the keys on the spider leg; the space blocks are held in place by the pressure of the spider heads.

The core discs, or sections, two in number, as shown, are made up of the thin discs which are stamped out of pure wrought-iron sheet and laminated to form the sections, the lamination affording means of breaking up Foucault or eddy currents which would tend to heat the core; the laminations are about .025 inch thick, and are japanned on both sides; each core section is 2¼ inches thick. The slots for the armature winding and key-way for the spider leg are stamped into the discs and when the sections are pressed into form the key-ways and slots are trued up by filing; the inner and outer lamination of each section has teeth for securing to the space block, but the discs are not bolted together, being held in shape by the pressure of the space-block rings and bored next to the spider for the through bolts from the rings, *K*.

The commutator is mounted on the extension of the hub of the spider and is driven by a key. The shell, *V*, is provided with arms which admit air through the commutator, thus cooling it and also assisting in keeping up a current of air through the interior of the armature. The inner end of the commutator shell, *Q*, toward the armature core is flanged off, and two of the surfaces are finished at suitable angles to support the back of the commutator bars. The front end is fitted with a similar ring which clamps the commutator bars together and is drawn in by bolts, *Z*. The commutator bar is shown in longitudinal section at *S*; it is made of hard-drawn copper and is insulated from the shell by mica. The back of the upper surface of the commutator bar is milled to receive the ends of the leads or connectors for the windings, ½. The commutator is 30 inches in diameter and 10⅜ inches long, giving good radiating surface for the heat of friction and resistance losses due to the use of carbon brushes.

There are 350 commutator bars, or two bars per slot.

The armature winding is of the multiple-drum type and consists of 1400 conductors of bar copper .07 inch by .075 inch. There are eight conductors per slot insulated from each other, and before being placed in the slots, on the lap-wound principle, they are formed together, the method being known as the Eickemeyer winding.

[NOTE 18.—Generally speaking, bar windings in an armature are preferable to wire windings as they permit of lower heating guarantees and higher efficiencies due to the fact that more copper can be placed in a given slot; a wire winding would have a number of air spaces between the wires, whereas with a bar winding these air spaces would be reduced to a minimum and filled with insulation only. Bar windings are not practicable with small generators for mechanical reasons; for example, a 10 k. w., 500-volt machine would have approximately 20 conductors per slot, requiring 10 clips per slot, and their connection would be mechanically impossible. The limitations of the employment of the bar or wire for armature windings is the size of the conductor and the number of conductors per slot; if the cross-section of a conductor exceeds that of a No. 4 B. & S. G. wire, and the number of conductors per slot are 8 or less, a bar winding is preferable.

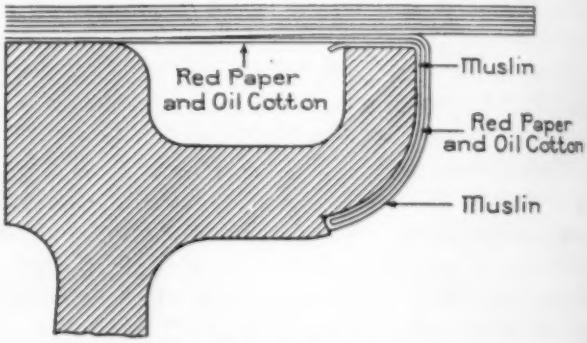


FIG. 93.—Flange insulation.

The Eickemeyer type of winding consists essentially of a series of insulated coils exactly alike, with the portions on the end of the armature core so formed that, where two adjacent coils cross each other, there will be a space intervening between the underlying portion of one coil and the overlying portion of the other. It has several advantages: there is absolute uniformity in the winding construction, as the formed coils are alike; the coils are firmly secured and not so likely to abrade the insulation as in other forms of drum-winding which are more or less loose; the coils are readily removable and interchangeable, hence repairs are easily made; there is more uniformity in resistance in the several circuits; there is economy of space; and more perfect insulation is practicable. In the Eickemeyer method the windings are laid on, or wedged into, the periphery (into the slots), and are clamped in place by bands screwed to the back and front of the armature, or merely held in the slots by the clips and connectors, making a decided improvement over the usual drum-winding; as compared with the Gramme ring-winding, not drum-wound, only those conductors are used which are represented by the peripheral part of that type of winding and cross-magnetization is lessened.]

Where the ends of a winding are to be connected to the commutator bar they are soldered to a copper clip which embraces the two ends; the lower edge of the copper clip is pinned and soldered in the milled slot of the commutator bar.

The armature insulation is generally considered in three divisions: the **flange insulation,** which refers to insulation over the flanges of the rings, *K*, Fig. 1; the **slot insulation,** and the **insulation of the bar conductors,** or **insulation of the winding.**

The method of **flange insulation** is illustrated in Fig. 93. Over the end of the flange is placed one layer of muslin, one end being

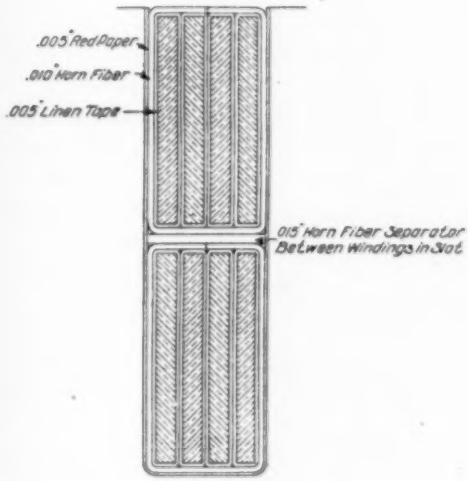


FIG. 94.—Slot insulation.

allowed to remain hanging. Over this and extending the entire width of the flange are placed three layers of red paper, each .009-inch thick, and two layers of oiled cotton, each .007-inch thick, arranged alternately, paper first. This insulation is of sufficient length to fold over the end of the flange, where it is pasted, after which the end of the muslin remaining hanging is brought up and over this insulation, forming a finish. Layers of pressed board are placed over this and built up flush with the bottom of the slot.

The insulation of each slot (Fig. 94) consists of one piece of .005-inch oiled red paper cut to such a size that when pressed into the slot it will project about ½ inch above the top of the

slot and ⅜ inch beyond each end. After the coils are in place the insulation projecting beyond the top of the slot is trimmed off flush with the surface of the armature.

For the **insulation of the winding** (Fig. 94) each bar is taped with .005-inch tape butted through the slot part and one-half lap outside of the slot. Each bar is then brushed with shellac over the slot part with 2½ wraps of .006-inch varnished bond paper with the lap on the top. Over this is cemented a .010-inch piece of horn fiber (Fig. 94) with the edges butted in the center on the top of the coil. Between the upper and the lower layers of the winding in the slot is placed a .015-inch horn fiber separator which projects ⅝ inch beyond the ends of the slot. Between the windings outside of the slot and over the flanges are placed .020-inch fiber separators extending from the armature punchings to the inside of the clips which connect the top and the bottom layers of the winding. Over each of these separators is laid a narrow piece of .030-inch horn fiber placed close to the clips.

The commutator leads are not taped but are given a coat of air-drying japan.

No top sticks are used in the slots of this armature.

The binding wire consists of two bands over each section of the armature core, and two bands over each flange. The four flange bands consist each of 12 turns of .072-inch steel wire; the inner bands over the sections are of 10 turns each of .042-inch phosphor bronze wire.

Equalizing Rings.—A feature of this generator is the use of equalizing or balancing rings, shown in section in Fig. 89, *R*, on the back of the armature; their object is to maintain the brushes of the same polarity at the same potential. They are sometimes called Lammé rings.

[NOTE 19.—The explanation of the use of equalizing rings is as follows: In large multipolar, multiple-wound, direct-current, machines, the potential generated in a conductor under one pole sometimes exceeds or falls below that in a similarly situated conductor under another pole of the same polarity. This may be due to difference in the pole strengths at the two poles; to differences of winding and construction; the armature may not be central in the magnetic field (out of magnetic balance) from the sag of the shaft or from magnetic pull on the bearings; or the brushes may make unequal contact on the commutator; the result is that a current corresponding to the difference of potential till flow from one section of the winding to the other through the brushes. This current will act in the same way as

if two generators were rigidly connected on one shaft and the potential of one was raised above that of the other, the former would run the other as a motor; the result of the unbalanced current is bad sparking, excessive heating of the windings and burning of the brushes.

The actual method of equalizing the brush potentials by equalizer rings is shown in the large armature of Fig. 95. The rings are continuous conductors secured to the back of the armature and insulated from it.

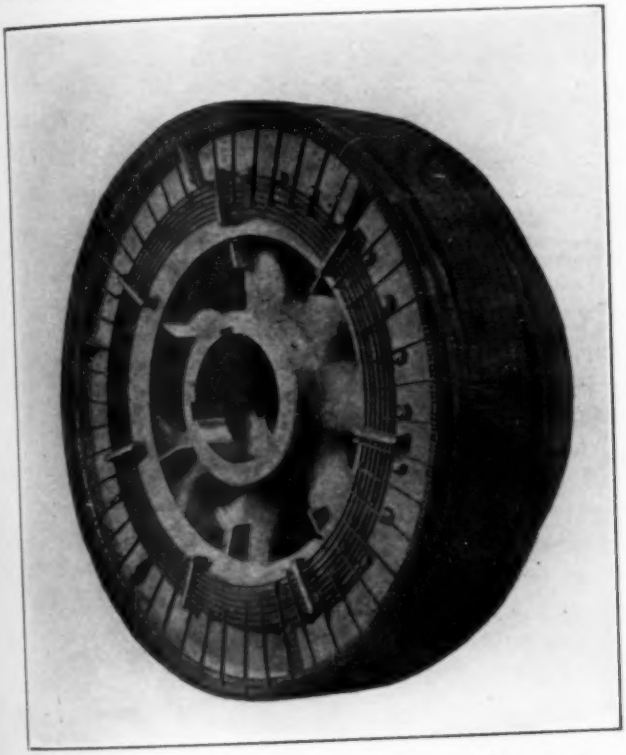


FIG. 95.—Example of armature with equalizing rings.

A diagram of the general method of connecting is shown in Fig. 96. From the winding at the periphery, and in sections corresponding to the number of pairs of poles, connecting leads from parts of the winding, which in the different sections will be simultaneously in the same position in regard to the fields, are tapped to the same equalizing ring. Hence if any difference of potential exists for any part of the winding tapped to the ring, the ring forms a short path for equalization independent of the windings or brushes. The current which will flow will be seen to be an alternating current, leading in some coils and lagging in others, enabling a small current to establish the balance. The armature will be in magnetic

balance with important variations of position in the field due to lack of alignment of the shaft; in fact *such an armature will not indicate that it is not central in the field by a test for magnetic balance.*

The following somewhat extreme cases of the effect of equalizing (Lammé) rings have been reported:

An electrolytic generator ran for two years with one of the shunt exciting coils reversed.

A generator, 810 k. w., 180 volts, 4500 amperes, ran for three weeks with two coils reversed without material difference in performance.]

The Brush Assembly, or Brush Rigging.—Ten brush studs, two of which are shown in Fig. 89, A^1, A^1, are tapped into the carrier, or rocker, and on each stud are fitted five brush holders each carrying one carbon brush.

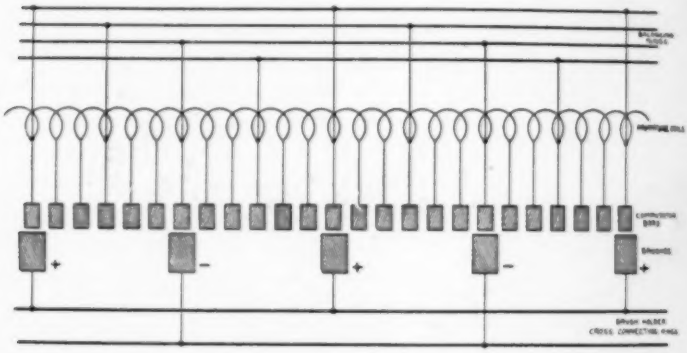


FIG. 96.—Diagram of method of connecting equalizing rings.

The brush holder is shown in Fig. 97. It consists of a brass casting having a bore which is machined to slip on over the brush-holder stud, the bore is split at one side and sprung to be tightened or loosened on the stud by a screw. On a barrel in the jaws of the casting is a stiff steel spring whose end is curved and extended to take on the top of the brush, the pressure being regulated by a lever operating the barrel, and which lever can be retained in place by pawls on one side of the jaw. To one end of the casting is secured a cast or bent brass box having flanges to bolt to the former casting. A screw on top of the casting secures the clip of the connector or "Pig Tail" of the brush.

In securing the holder on the stud care should be taken that the lower, beveled edge of the box holding the brush is parallel to the surface of the commutator.

The brush (Fig. 97) is of carbon and is 1¼ inch by 1 inch by 1½ inch. It is coated with copper for three-fourths of the length and is capped with a piece of brass. The connector or

FIG. 97.—Brush holder and carbon brush.

pig tail is soldered to this piece of brass and to its other end is soldered a copper tip, whose jaws embrace the set screw on the top of the holder.

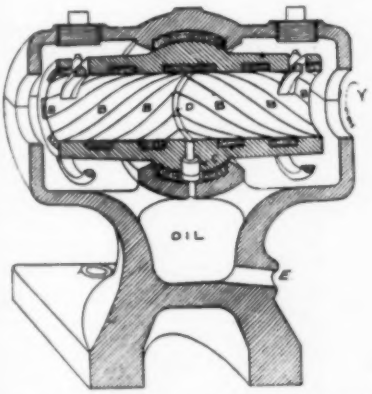


FIG. 98.—Outboard, or ring oiler, bearing.

The Outboard Bearing (B^1, Fig. 89).—This is also called the pillow block bearing and the ring oiler bearing. The bearing is shown separately in Fig. 98.

The bearing itself is a sleeve held in the pillow block by a ball

and socket joint, and hence is self-aligning. The lower part of the pillow block forms a reservoir for oil. Two slots in the upper part of the sleeve are cut transversely, one near each end, exposing the upper surface of shaft at these places. Two rings (*AA*, Fig. 98) dipping below the surface of the oil in the reservoir, rest on the exposed parts of the shaft and are driven by it. The sleeve is cast iron. On the bearing surface of the sleeve, spiral grooves (*BB*) are cast, running right-handed from one and left-handed from the other end. These grooves are filled with babbitt metal, the bearing surface thus consisting of spiral bands, alternately babbitt and cast iron. A groove (*D*) is cut around the middle of the sleeve, where the spirals meet; it communicates with the oil reservoir by holes (*C*) in the ball of the sleeve and the socket bearing of the pillow block. The oil may be drawn off from the reservoir by a pet cock screwed into a hole (*E*) in the pillow block.

When a machine with bearings of this construction is running, the motion of the shaft keeps the rings (*AA*) continually revolving and carrying oil from the reservoir to the ends of the bearing. The oil delivered at the ends of the bearing is swept towards the middle of the sleeve by the action of the revolving shaft on the spirals. At the middle of the sleeve the oil is collected by the groove (*D*) and returns by the hole (*C*) to the bottom of the reservoir where it has time to settle and cool.

Depending only on the motion of the shaft, the oiling action of this bearing is entirely automatic. Starting the machine starts a flow of oil through the bearing which is continually maintained whilst the machine is running and stops the moment the machine is stopped.

An arrow is cast on the upper surface of the sleeve, and the latter must be set so that the upper surface of the shaft runs in the direction the arrow points.

It is recommended that these bearings should be examined once a week, although the oil does not need to be renewed as often as that.

[NOTE 20.—The action of the carbon brush in producing *natural*, or *resistance commutation*, and of the pole pieces in producing *forced* or *magnetic commutation* (both methods being combined in the design of the 100 k. w. generator), are to ensure sparkless commutation in the operation of the machine.

Natural, or Resistance Commutation.

The very general use of carbon brushes is due to the greatly reduced sparking at these brushes as compared with copper; the larger number used is due to the difference in carrying capacity, for while a current flux of 250 amperes to the square inch may be allowed for copper brushes, only from 30 to 40 amperes to the square inch are allowed in carbon designs, and in practice it is found to be better to keep below the lower limit. The necessary carrying capacity is obtained by putting more brushes on the same stud. For high-speed commutators a higher current density is usually preferable, in low speed commutators a lower current density.

The better service of carbon brushes in producing sparkless commutation is, in some details, still a matter of controversy; the difficulty seems to be in examples taken from different designs which have been constructed on the various theories, and from which an actual, final determination has not been exactly crystallized; in short the empirical factors form the contention in view of the fact that the mathematical are too involved for integration.

The voltage generated in the armature of a constant potential, direct-current dynamo is actually an alternating voltage; constant, non-alternating potential is effected by "commutation," which is obtained by dividing the armature winding into a number of divisions, or separate coils, whose ends are connected in series by attaching the end of one coil to the beginning of the next, through connections at a segment of the commutator, and taking off the current by means of brushes. The brushes change, "commutate," the tendency to assume the negative values of alternation and make them positive; the complete revolution of any single coil, therefore, produces cycles which are not alternations of positive and negative directions of the current, but a succession of positive directions. Perfect commutation for constant potential would consist in having an infinite number of coils and thus prevent the pulsations of practice; but mechanical considerations, and the necessity of insulation between the commutator bars, limit the number of coils in practical design.

In the act of commutating, or reversing, the current, the sparking of commutation is produced, and may be of two kinds, the non-deleterious or "blue-spark," and the deleterious, "vicious," or yellow spark; the blue spark appears because the current producing it is small, while the yellow results from the heating effect of a current sufficiently large to volatilize the copper of the commutator bar and be carried to that edge of the bar which the brush leaves; this will account for the increased sparking with increased load. As the melting and volatilization takes place at the side of the bar which first comes in contact with the brush, that edge will be left smooth and no sign of injury will be noticed until sparking begins; this seems to explain why a machine, originally commutating sparklessly, will show sparking after a little use, and why the sparking can be stopped temporarily by turning down the commutator.

The problem of sparkless commutation resolves itself into automatically preventing the current producing the volatilization of the copper of the

commutator bar, or at least in reducing it below a value which will produce melting and volatilization.

Fig. 99 shows six diagrammtic developments of five commutator bars *A, B, C, D, E,* which connect in series the four coils *a, b, c,* and *d.* The positive brush is shown and made smaller in width than the segments, for

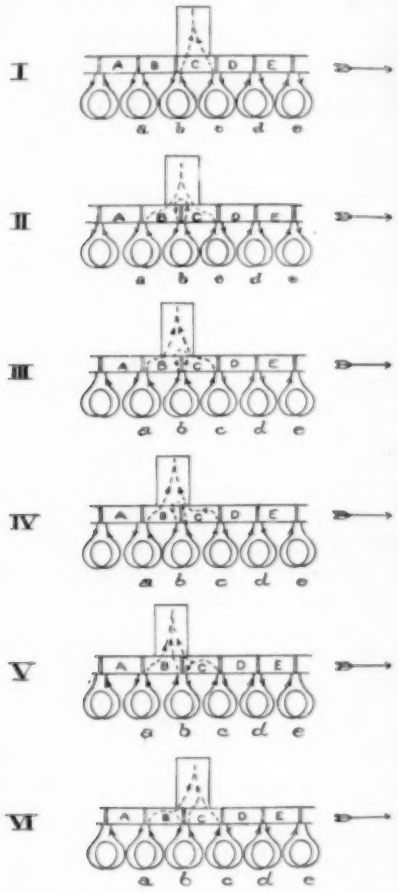


FIG. 99.—Illustrating resistance commutation.

the purpose of illustration. A current is assumed to be flowing into the negative brush, and to be dividing itself to flow up both sides of the armature, the direction of flow in the coils *a, b, c,* and *d* being indicated by the arrows.

In I are shown the conditions when the brush is in contact with the segment *C* only, and when the currents from each side of the armature

are collecting in the brush without other hindrance or effect than the resistance of contact between the brush and the commutator bar.

In II one fourth of the brush contact has passed over from *C* to *B;* the current in the coil *a* has been afforded a short path to the brush and its current no longer passes through *b;* the coil *c* still passes its current into the brush; the coil *b* has been short-circuited, as the brush now bridges both segments *B* and *C*, to which it is connected, and no current due to that coming from the negative brush is circulating in it. Just as the brush came in contact with *B*, however, an electromotive force was generated in *b*, due to self-induction, and a current was set up in the closed circuit of *b* proportioned to this electromotive force and the resistance of *b*, which is tending to gradually discharge itself.

III and IV are the conditions when the brush area of contact is one-half and three-quarters on *B*, respectively, and in which the paths for the current from *B* has proportionately less resistance and that from *C* proportionately greater; the induced voltage in *b* has meanwhile been discharging itself.

In V are shown the conditions just as the brush is to leave the segment, *C*, when the contact area of the brush on *C* has become very small and has introduced a large resistance, comparatively, to the flow of current from *C* to the brush; the current now divides itself in inverse proportion to the resistance, part going into the brush direct from *C*, and part going through the coil *b*, which is assumed to have (or should have) discharged its induced current.

Considering the conditions of V, if the current which is passing direct to the brush from *C* is comparatively large, it will, when assisted by the electromotive force induced at the time of the breaking of the contact of the brush with *C*, have sufficient value to cause a spark to arc over from *C* to *B;* the value of the current which, just before breaking contact, was passing from *C* to the brush, will depend upon the resistance afforded by the area of the brush. If the material of the brush be *solid* copper the resistance afforded will be low and the value of the current will be comparatively high; if the material be *copper leaves* or *copper gauze*, or the entering and trailing sides be reinforced by a strip of resistance metal such as German silver, the resistance will be greater than that for solid copper and the tendency to sparking will be decreased; if the material be *carbon* the resistance will be high and the value of the current proportionately low and comparatively insufficient to cause a spark.

In VI is a condition, intermediate between I and II, in which the status is the same for the moment after contact of the brush with *B* as *V* is for moment before breaking contact with *C;* only a small part of the current from *a* is flowing into the brush from *B*, while the major part goes by way of *b*. As the current due to the voltage of self-induction is flowing into the block, *B*, in an opposite sense to that coming directly from *a*, it opposes the current coming from *a* and reduces its value; hence, there should be less tendency for a brush to spark deleteriously in making contact on its entering edge, the tendency is limited to the trailing edge only;

there would be heating but the temperature would not be great enough to produce a spark.

Two things are, therefore, necessary in resistance commutation to sparkless commutation: *First*, the induced current must have discharged itself before the brush has broken contact with *C*, this the material of the carbon brush assists by giving high resistance in the short circuit. The element of time is an essential factor in assuring this discharge, and the time between making contact at *B* and *C* is extended by making the brush width greater; the brush is usually made wide enough to space two to three bars of the commutator, but the width is affected by the general design of

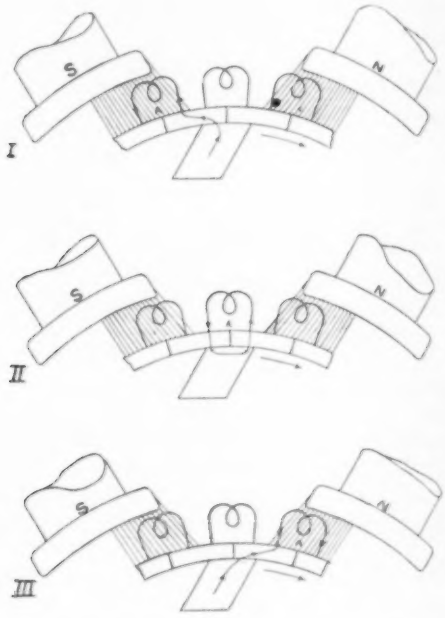


FIG. 100.—Illustrating magnetic commutation.

the dynamo. *Second*, the resistance to the flow of any current from *C* to the brush at the time of breaking contact should be great enough to reduce the current to zero before the break occurs; evidently carbon is preferable to copper for the purpose.

Forced, or Magnetic Commutation.

This method is that which is due to the effect of the "fringes" or magnetic lines of force from the pole pieces. A coil leaving the magnetic field of a pole and entering that of another is under three conditions, as shown in (Fig. 100), I, II, and III.

In I the coil *A* is under the field of the pole, *S*, and is generating a

voltage which is taken from the commutator bar through the brush (placed inside for illustration) in the direction of the arrow.

In II the coil *A* has left the field of the coil *S* and has progressed in rotation to *B*, where it is short-circuited by the brush now bridging the two commutator bars to which the ends of *C* are connected.

In III the coil *A* has entered the field of the pole, *N*, and its current now circulates in the opposite sense to that of the position of *A* in the field of *S*. The arrows indicate the circulation of current in the coil in the two positions.

In II the current flowing around *A* when short-circuited is not one generated due to the field but only to self-induction; in order that there be no sparking, as the right hand segment of the commutator, to which *A* is connected, leaves the brush, it is necessary that this current be reduced to zero and built up again to circulate in an opposite sense to that before short-circuit; to accomplish this, the pole pieces are shaped to have the effect of fringing out the field of *N* toward the position of *A-B* and thus bringing *A* gradually under the influence of its field. Applying this to the fringe of *S*, the field action would be to delay the waning of the current in *A* to nearer the point of short-circuit and sustain the voltage; but the feature desired is the early reversal of the current in *A* between the point of commutation and the dense field of *N*.

That forced commutation alone has not proved successful in obviating sparking, with varying load and fixed position of brushes, points to the fact that resistance commutation is the important factor within the limitations of its adaptability to the particular design and, as before shown, carbon brushes accomplish the greater part; the efficiency resides in the resistance of contact.

Carbon brushes introduce a loss in generator efficiency due to the resistance of contact and to friction, both largely in excess of the values obtained with copper brushes; but the general efficiency of operation, without change of brush position with load, have made it commercially desirable to increase the radiating surface of the commutator to keep the extra heating within acceptable limits, the increased cost and loss in efficiency being offset by the advantages of operation.]

There are designs of the form H type of the General Electric Company, having inside governors, for 75, 50, 32, 24, and 16 k. w.; and all the sizes, except 75 k. w., are installed or in use in the service. The engines of all sizes are modelled on the 100 k. w. with variations in parts according to size but carrying out the general plan.

The generators below 100 k. w. are series-wound, wave-wound, drums, having a lever arm rocker which can be locked by the lever; the connecting arcs are used in all.

A 100 k. w. set for the *Georgia* showed:

Engine efficiency	92.7 per cent.
Dynamo efficiency	90.8 per cent.
Overall efficiency	85.0 per cent.
Water consumption (k. w. hour)	27.5 pounds

The governor regulation of speed and voltage complied with specifications over the whole range of steam pressures and vacua for the variations of load.

The compounding came well within permissible variation, and once set at a lead of 8 bars, 1.88 inches, there was no sparking between no load and 33 per cent overload, no change being made in the brush position.

CHAPTER VI.

GENERATING SETS (Continued).

Form G—General Electric Company.

This type is generally spoken of as the tandem-compound combination, from its style of engine; the M. P.—6-32-400, 80-volt design is shown in Fig. 101. After eight years' service experience it appears to be commonly agreed amongst those who have had to do with its operation and repair that this type of generating set has proved most satisfactory. The remark is derived mainly from the endurance in operation of its engine, the modern dynamo requiring little repair, accidents apart, during the life of its brushes and commutator. The engine, having fewer working parts than the cross-compound, has a good margin left within the limits of weight for a strong, sturdy construction, and ample bearings. It proves to operate quietly and continuously under a minimum of repair and adjustment; it shows good efficiency and economy after ordinary use; the wear of parts is small with large surface and forced lubrication; and it has the distinct advantage of a reduced number of small working parts to be replaced, or get out of order, or break—an important matter in vessels of war whose personnel is continuously changing, and whose immediate available skill for operating and caring for the particular plant may be somewhat in question.

The objection to the tandem-compound type of engine which has debarred it, in that the official specification prescribes a cross-compound, is the head-room required in the compartment on board the ship in which it is to be installed; in the light of recent developments as to accession of oil in the cylinders the objection is much modified for generating sets of 50 k. w. and under, as there will hereafter be but unimportant difference in height between the tandem and cross-compound types; for a size of 100 k. w. the height necessary to the tandem-compound engine would probably be too great for present-day ship dynamo rooms; there has been, however, no design of a tandem-compound gener-

ating set of over 75 k. w., commercial capacity, at 125 volts, which last is the same in its engine as the 50 k. w. size at 80 volts.

There is a difficulty which is to be remembered in connection with the tandem engine construction—it is more a difficulty than an objection—and that is the difficulty in removing the intermediate head between the cylinders. While the difficulty may aid in obviating the necessity, the stuffing-box between the cylinders

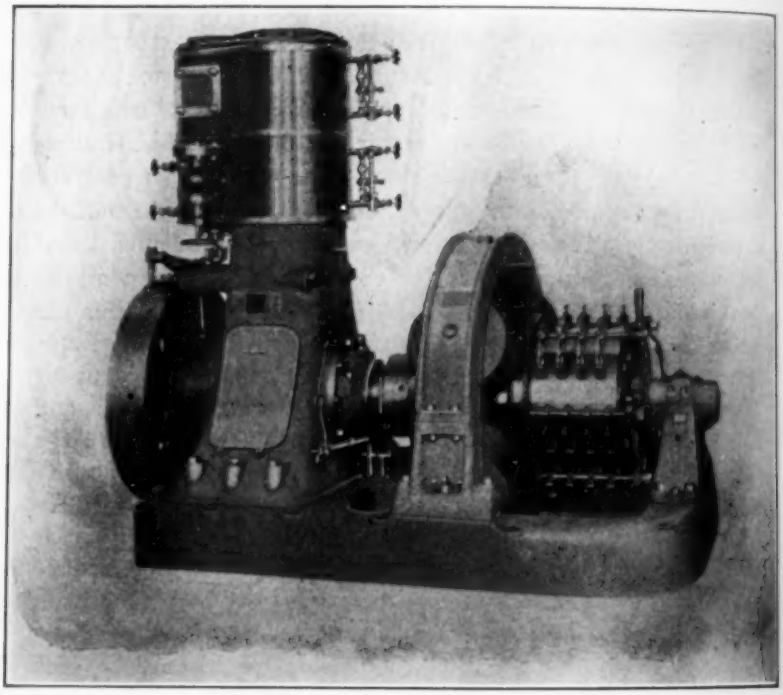


FIG. 101.—General Electric Company's Form G (tandem-compound) generating set.

(and through the intermediate head) has no other lubrication than that derived from the steam, and the intermediate head requires to be taken out when repair and thorough examination of the stuffing-box is necessary.

The standard line of designs embraces the 50, 32, 24, and 16 K. W. sizes.

Features of the Engine.

The engine is shown in cross-section in Fig. 102. The steam pressure is 100 pounds; rated exhaust, 25 inches or atmospheres.

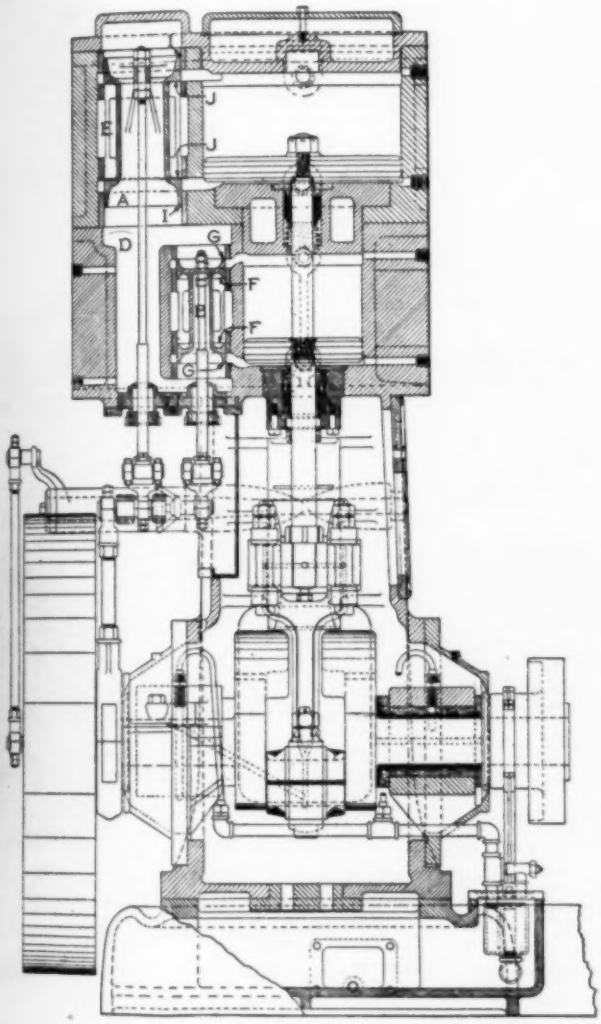


FIG. 102.—Cross-section tandem-compound.

The **steam distribution** is effected through two cast-iron, balanced, piston valves, *A* and *B*. Timed by the movement of the

valve *B*, the steam enters the high-pressure cylinder chest and valve through the throttle valve, and after doing work in the H. P. cylinder is exhausted into the receiver *D;* thence, it is admitted into the low-pressure cylinder by the valve *A*, the steam passing through the body of the valve *A* when admitting to the top of the L. P. cylinder; the steam is finally exhausted through the passage *E*. The H. P. valve takes steam on the inside, the admission edges being at *FF* and the exhaust edges at *GG;* the steam lap is ¾ inch; the exhaust lap, top and bottom, is zero. The travel of this valve is controlled by the governor and varies

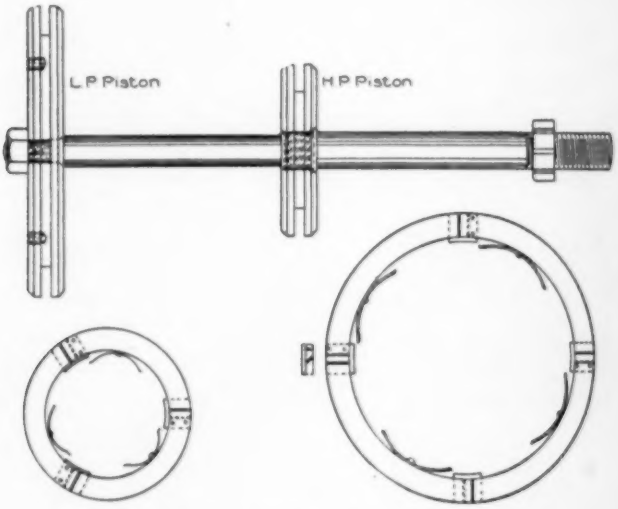


FIG. 103.—Pistons, piston rod and piston packing.

between 3 inches and 1⅜ inches; the cut-off varies between ¾ and zero, depending on the load. The low-pressure valve takes steam on the outside, the admission being at *II*, and the exhaust edges at *JJ;* the steam lap is 1 1/16 inch and the exhaust lap is, top, zero; bottom, 1/16 inch. The low-pressure valve has a fixed stroke of 3 1/16 inches, giving a cut-off in the cylinder of about ⅝ stroke.

The casing or **column** is tapered and made strong to support the cylinders and is well secured to the bed-plate. A door gives entrance to the interior and casings enclose both shaft-bearings.

There is but one **crank,** hence only two main bearings are neces-

sary. The shaft coupling is in one with the shaft, with usual provision for the radial key and bolts; at the opposite end the fly-wheel—carrying the governor—is overhung on the shaft and between this wheel and the casing is bolted the eccentric for actuating a rock-shaft, which in turn operates the low-pressure valve. There is also an eccentric between the coupling and the casing; this operates the pump for the forced lubrication system.

The shaft-bearings are similar to those of the form H.

The low-pressure piston (Fig. 103) is a cast-iron disc with a single rectangular groove, which receives the piston packing.

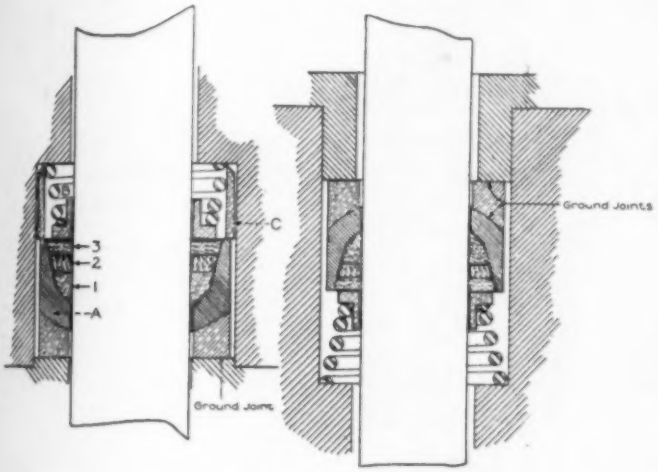


FIG. 104.—Single junior piston rod packings.

The piston is screwed on the rod against a taper shoulder and is secured by a lock nut in the face of which are radial grooves; a split pin through the rod lies in one of the grooves in the nut preventing the nut from working loose.

The high-pressure piston (Fig. 103) is of steel; it is screwed to the rod and riveted.

The piston rod is of forged mild steel. It is threaded at the lower end and is screwed into the cross-head and locked by a spanner jam nut.

[NOTE 21.—**To assemble the pistons,** place the high pressure piston packing in place and bind with cord or wire; take off the low pressure piston and put the high pressure piston in the cylinder; as the packing passes

the end of the high pressure cylinder the cord or wire will be pushed off (if not, remove it); then place the intermediate cylinder head on the rod and secure it in position; pack the stuffing box and screw down the gland tight. Place the low pressure piston packing in place and secure it as was done with the high pressure packing; place the piston on the rod, removing the cord or wire.]

The L. P. piston packing (Fig. 103) consists of four cast-iron arcs, overlapping at the ends and made steam tight by brass tongues, one of which is riveted to each arc. The packing is held against the cylinder wall by flat steel springs, one of which is fastened to each arc.

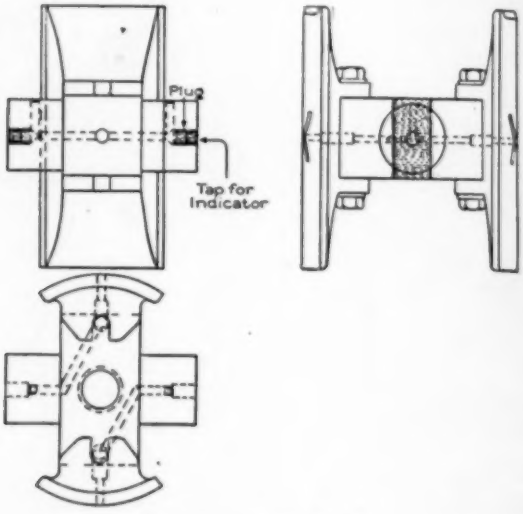


FIG. 105.—Cross-head.

The H. P. piston packing is of the same construction as that for the L. P., except that there are but three arcs.

The piston-rod packings are known as the Single Junior type, and are shown in Fig. 104.

The H. P. packing (left hand of figure) consists of a vibrating cup, *A*, receiving the babbitt metal packing rings 1, 2, and 3. These rings are in halves and should break joints in assembly. The vibrating cup has a spherical bearing so that the packing will follow the rod in any position. The steam pressure forces the packing down in the cup and against the piston rod, thereby preventing the leakage of steam. The coil spring *B* assists the

pressure, at the same time holding the packing in place and preventing the rings from following the rod at the moment of reversal. The vibrating cup is held in position by the space ring *C*.

The L. P. packing (right hand of figure), is similar to the H. P. packing, except that no space ring is used.

Whenever this packing is overhauled care should be taken that it is free of grit before reassembly.

The throttle valve is of the 90-degree angle Lunkenheimer type, looking up.

The cross-head (Fig. 105) consists of a rectangular steel

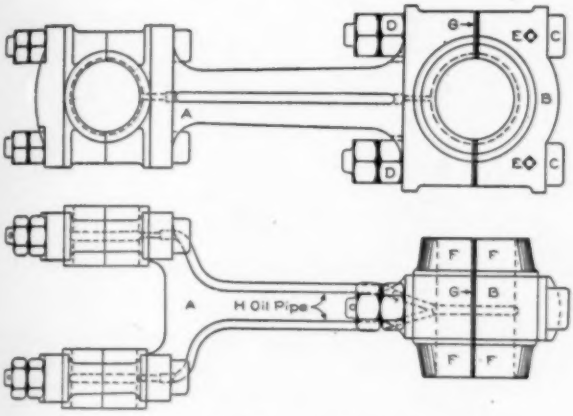


FIG. 106.—Connecting rod.

block with two cylindrical projecting parts which form the wrist pins. Curved composition slippers are fastened to the cross-head by tap bolts; wear is taken up by inserting liners between the cross-head and the slippers.

The method of conveying oil from the pin to the guide is shown in the illustration.

The connecting rod (Fig. 106) consists of a forged steel body, *A*, forked at the upper end for receiving the wrist-pin brasses, each set of which is held in place by two through bolts with double nuts and split pins. Wear is taken up by filing the faces of the brasses.

The lower end of the rod terminates in a stud to which the crank-pin box is secured by a steel cap *B* and two bolts *CC*, with

double nuts *DD*, and split pins. The set screws *EE* are for the purpose of preventing the turning of the bolts *CC*. The crank-pin bearing consists of a cylindrical cast-steel shell *F* in halves, having two small flanges which engage the connecting rod and prevent lateral motion of the shell; turning of the shell is prevented by through bolts and liners. The interior of the shell, which comes in contact with the shaft is babbitted, and wear can be taken up by removing the fiber liners *G*. It is important that the boxes in this, as well as in the top bearing, be always tight, in order to avoid the leakage of oil, which must be forced from the lower bearing through the pipes *H* to the wrist pin and the cross-head guide.

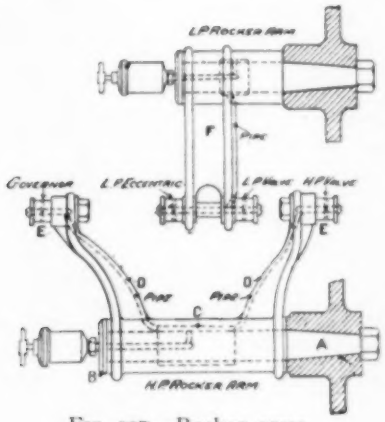


FIG. 107.—Rocker arms.

The valve motion is accomplished through the valve stems by the two **rocker arms** shown in Fig. 107. The lower one in the figure is actuated by the governor connecting rod, and gives motion to the high-pressure valve; the upper is actuated by the l. p. eccentric and gives motion to the low-pressure valve. Each rocker arm bears on its stud *A* which passes through the column and is secured by a nut. The washer *B* at the end of the stud *A* is tapped for a screw grease cup which forces the lubricant to chamber *C* in the rocker arm, from which it is further forced through pipes *DD* to the journals *EE*.

The valve stems are threaded at the lower end and screwed into a small cross-head (Fig. 108), to which they are secured by lock nuts; the central portion of this cross-head is square and

the ends are cylindrical, forming bearings with the link, *B;* the the bearing caps *CC* for the pins are each secured by two bolts screwed in the bottom half of the link and locked by a nut;

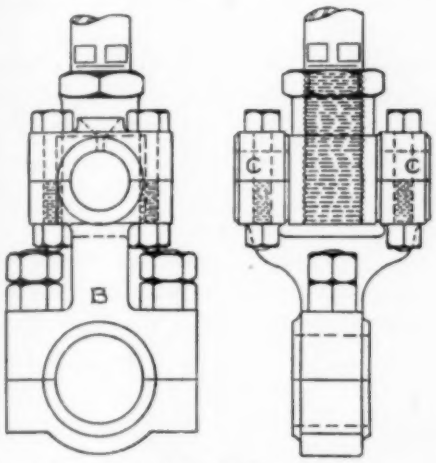


FIG. 108.—Valve stems and links.

wear is taken up by filing off the faces of the caps. The lower end of the links contains a bearing, similar in construction, which receives a pin fixed in the rocker arm; here also wear is taken up by filing the cap faces.

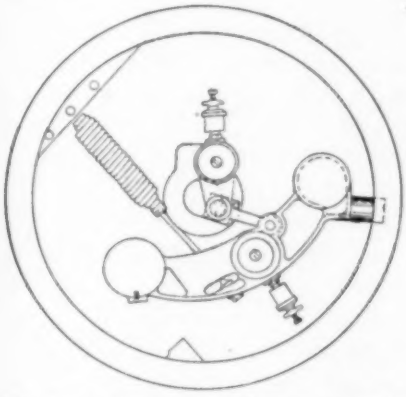


FIG. 109.—Governor, tandem-compound.

An indicator reducing motion is attached to each engine. By removing the nut on the end of the inboard rocker arm stud, a

bracket may be attached and the nut can be replaced; a stud projecting from this bracket forms the fulcrum of the pendulum; the opposite end of the pendulum is slotted and receives the end of a stud, which can be screwed into the cross-head bearing when the oil cup is removed.

The governor (Fig. 109) is contained in a heavy fly-wheel keyed on the end of the shaft. The method of control of speed is similar to that described for the 100 k. w. type.

The ideal grease cup (Fig. 110, *A*) is provided with a leather-packed plunger against which rests a coiled spring. The spring and plunger are conveniently controlled by a thumb-nut; turn this to the right until the plunger is raised to the top of the cup, unscrew the cover and fill the cup with grease, replace the cover and adjust the pressure on the grease by the thumb-nut, allowing

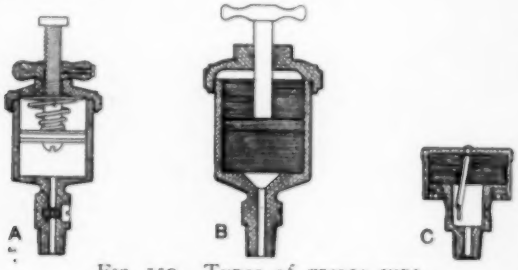


FIG. 110.—Types of grease cups.

the spring to press on the plunger forcing out the grease. The rate of feed may be regulated by the set screw in the lower part of the cup in which there is a hole in line with the slot.

The "marine" grease cup, No. 1 (Fig. 110, *B*), is used for forcing the lubricant to the rocker arms and the valve-motion pins.

The "tiger" grease cup (Fig. 110, *C*) is sometimes used on the engine and is different in operation from the two just described. By screwing down the cap the lubricant is forced to the bearing; a leather washer prevents the grease from leaking out of the cup and can be easily replaced when worn out; a spring locking arrangement, the projection of which engages at each turn, prevents the cap from jarring off, and also cuts and loosens the grease.

All of these types of grease cups are for use with Albany grease.

The system of **forced lubrication** used is shown in Fig. 111, and with the various parts already explained (see also description for the 100 k. w. type).

Features of the Generator.

The dynamo used with the form G type of generating set has been known as the M. P. form A, but is now included in the general letter of the type (G); the sizes are 16, 24, 32, and 50 k. w.

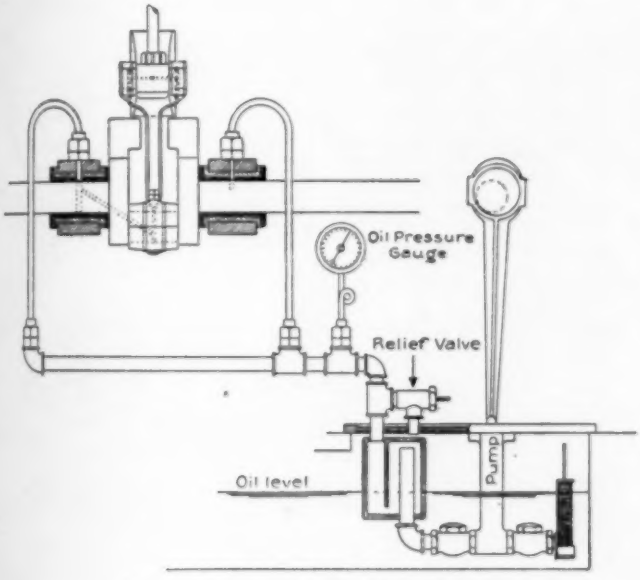


FIG. 111.—Forced lubrication system.

The 24 and 32 k. w. sizes have a speed of 400 r. p. m.; the 16 k. w., 450 r. p. m.; the 50 k. w., 310 r. p. m.

The Field Assembly.

This construction is in most respects similar to that described for the 100 k. w. machine, but there is no carrier framing (Fig. 101), a hand-rocker system being used with the machine instead.

The field winding has no ventilation spaces, otherwise it is as before described in other than dimensional and winding details.

The Armature.

The 50 k. w. armature shown in section in Fig. 112 is a typical example of the series-wound, wave-wound, barrel-wound construction; the series-wound feature is also termed a two-circuit winding.

The essential features in construction of the armature are the following:

The coupling is not forged with the shaft, but drives by a key in the key-way *B*.

The legs of the spider are joined together at the commutator end by a cast-iron disc *K*, which extends up to the line of the inner surface of the slots; between each of these legs are spaces

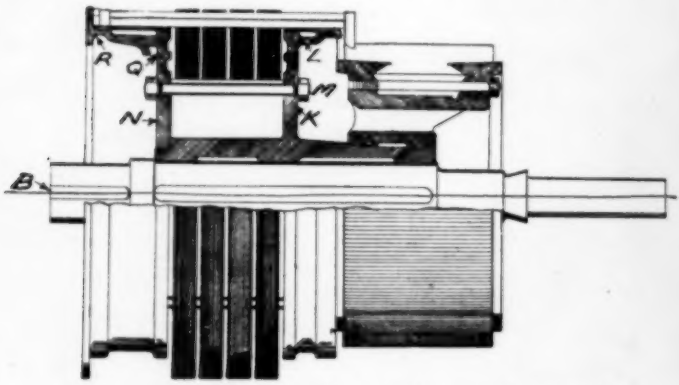


FIG. 112.—Details of 50 k. w. series-wound armature.

to admit of the circulation of air. The disc is flanged outwardly at *L* to support the extension of the windings which project beyond the slots; in this disc, and intermediate between the legs, are six bolts, *M*, which draw in place a similar disc, or follower, *N*, which supports the back end of the core and draws the sections of the core together; the follower *N* is further provided with a dove-tailed groove, *O*, in which metallic lead may be inserted for balancing, and there is an extension of its flange, *R*, higher than the windings, to throw off oil by centrifugal force, and prevent it from flowing back on the armature.

The armature core is made up in four sections, separated by space blocks for five ventilation spaces; in the 32 k. w. size there are but three sections, and in all other sizes, two sections.

The armature winding for a 32 k. w. size consists of 77 or 108 coils (there are two designs), each coil being made of two bars of copper 0.15 inch by 0.444 inch in multiple, no insulation being placed between the bars. There are two windings for each slot and top sticks of ash are driven to secure the winding in the slot.

The number of commutator bars is the same as the number of slots, which is a difference as compared with the multiple-wound generator.

The brush gear is shown in Fig. 113.

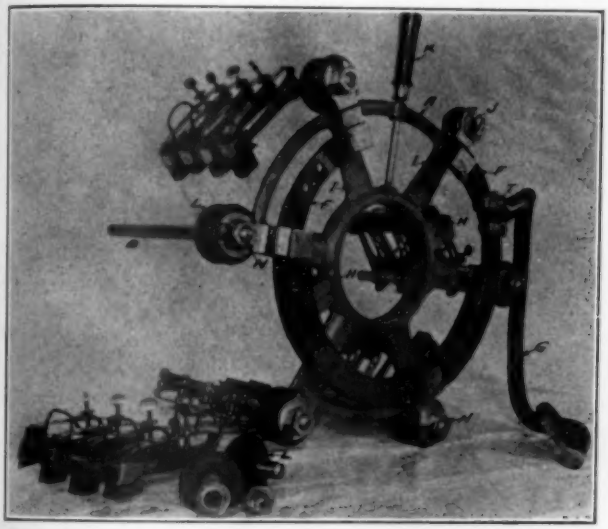


FIG. 113.—Brush gear design.

The rocker, *A*, is of cast iron and divided to fit over a flanged collar on the outboard (ring-oiler) bearing; it is loosely secured around the collar by the flange joints *H*. The arms *I*, one for each pole of the dynamo, are slotted in jaws at the end *J* for the studs. At the top and bottom are two cast masses for the clamp handle *K*; the upper mass is bored without tapping, while the lower is tapped, the clamp handle *K* can thus secure the rocker in any desired position by screwing down by the handle; the clamp handle serves also for turning the rocker around the collar of the bearing.

The brush holder stud, *B*, is a rod of steel which carries at the rocker end the insulator and securing nut. The insulator *L* consists of two discs of hard rubber or white fiber, which are separated from each other by a small bush of the same material as the discs (the bush is the cylinder forming the insulation between the stud and the jaw in the rocker end). A brass washer is placed outside the outer disc, and the brush connector clamped between the washer and the nut *N* on the stud end; the stud is thus in electrical connection with the brush connector *F*, but is insulated from the rocker.

The two **brush connectors,** *F*, are copper bars bent to the curve of the rocker to connect brushes of the *same polarity;* they are held in place by the nut *N* on the stud. To prevent accidental short-circuiting the connectors are covered with tape. The brush leads *G* are bolted to the connectors at *T* and to the insulated block on the dynamo frame; there is but one block on a board on the frame of machines smaller than 100 k. w., which serves for all leads.

The brush holder differs in construction from that shown in Fig. 97, but this latter type is now generally used on all types of machines, and the holder of Fig. 113 is falling into disuse.

Generating Sets for Torpedo-Boat Destroyers and Torpedo Boats—General Electric Company.

The generating set types for these uses are designed in two sizes, 5 and 2½ k. w.; the former is known as the M. P. 6-5-700 type, and the latter as the M. P. 6-2½-800. Both are similar in construction.

Especial Features of the M. P. 6-5-700 (80 Volts).

The set complete is shown in Fig. 114.

The Engine.—The engine is of the single-cylinder, vertical, double-acting, open, wrought-steel frame type, and has a speed of 700 r. p. m. at full load with 100 pounds steam pressure. The working parts of the engine are enclosed in a sheet-iron case (not shown) made in two pieces, which are removable.

The part of the bed plate extending out to take the dynamo frame consists of two cored arms, faced at the top for the dynamo frame flanges; in later types this construction has given way to the usual pillow block bearing.

The crank shaft is made from one solid piece of forged steel. The crank is machined out. Cast-iron counterbalance weights are cast on the crank webs over the cap bolts opposite the crank pins; a flanged coupling is shrunk and keyed on to the armature end for connecting with the flange on the armature shaft, a cored boss fits a corresponding recess in the armature

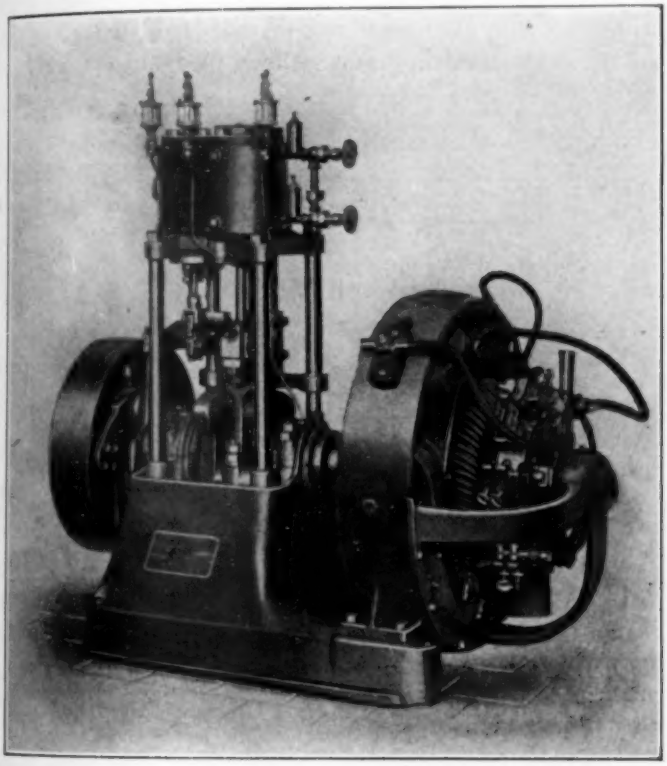


FIG. 114.—General Electric Company's M. P. 6-5-700, generating set.

shaft flange to assist in aligning. The shaft has a diameter of 1¾ inches at the main bearing and 1¾ inches at the crank-pin bearing. The crank-pin bearing is lubricated by oil from the main bearing next the generator, the oil being carried by centrifugal force through an oil hole extending through the shaft, crank, and crank pin.

The cylinder, valve chest, and stuffing box for the piston-rod packing are made of cast iron in one piece (Fig. 115). The diameter of the cylinder is 4 inches and the length of the stroke is 4 inches. The steam pipe is screwed into the boss, *A*, in the center of the steam chest. The exhaust pipe is at the back of the engine and at the bottom of the valve chest; it is screwed into the boss, *B*, and serves as a drain for the cylinder. The cylinder is tapped in front, both at the bottom and top (*C*) for indicator attachments; it is also fitted with a combined drain and relief valve, the drain consisting of a ¼-inch pipe and the relief valve

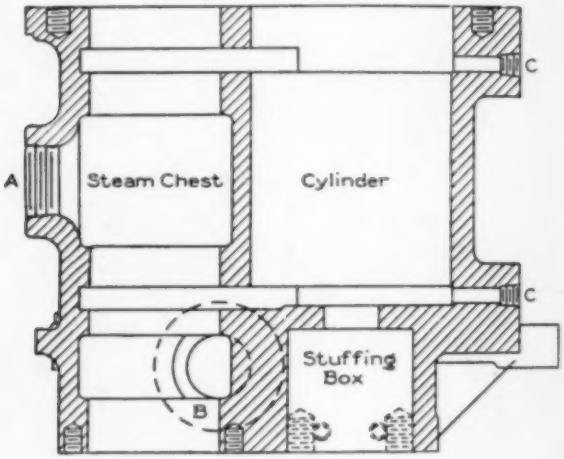


FIG. 115.—Cylinder casting.

of the usual pop valve. The cylinder head and the valve bonnet are made of one piece of cast iron and are fastened to the cylinder by nine ½-inch studs.

The valve is of the balanced piston type. The travel is controlled by the governor and varies between 1½ inches and ⅝ inch, varying the cut-off in the cylinder between ¾ and zero, depending on the load; the exhaust from the top of the cylinder passes through the center of the valve. At the upper end of the valve there are four webs connecting the inner circumference of the valve with a central boss to which the valve stem is attached. The steam lap is ⅜ inch, and the exhaust lap zero, top and bottom.

The valve stem consists of a mild steel rod ½ inch in diameter, the upper end of which passes through the boss at the upper end of the valve, and is secured by double nuts on each side of the boss; when set the nuts are locked hard together leaving the valve free to turn but without any play. Soft packing of good quality should be used in the valve-stem stuffing box.

The piston consists of a cast-iron disc, containing a cylindrical groove, which receives the piston packing ring. The piston fits on the taper on the piston rod, and is secured by a ⅝-inch nut on

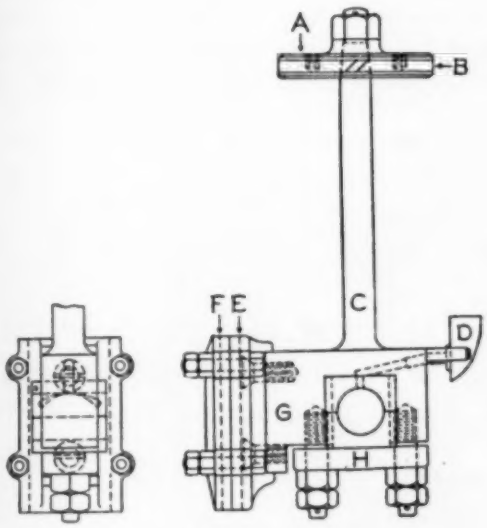


FIG. 116.—Piston rod and cross-head.

the upper side, in which is inserted the usual split pin to prevent the unscrewing of the nut. The piston packing is a single cast-iron ring overlapping at the ends and forming an angle joint.

The piston rod, *C*, and the **cross-head,** *G* (Fig. 116), are in one forging of mild steel. The cross-head shoe, *E*, is of gun metal and is fastened to the cross-head by two ½-inch flat-head screws, which are relieved of side pressure by the webs of the shoe. The cross-head is held against the guide bar by the clamp, *F*, which is connected to the shoe by four through bolts; the proper distance between the shoe and the clamp being maintained by ribs on the shoe and on the clamp. Wear may be taken up by

filing these ribs, but the filing must be done parallel to the wearing surfaces. The cross-head is slotted to receive the wrist-pin bearing which is made of gun metal, and is held in place by a cap, *H*, and two studs with double nuts. The bearing should be so adjusted that when the brasses are hard together the wrist pin will move easily but without play. Oil reaches the bearing from the oil cup, *D*, through a hole in the top of the bearing.

The rocker arm, *B* (Fig. 117), is a steel casting keyed to the rock shaft, *C*, which transmits motion to the rocker arm, *D*, with pin, *E*, which is attached to the governor connecting rod. The rocker arm is supported by a cast saddle, *F*, which is attached to the columns at the side of the engine and fixed in position by two through bolts. The lower end of the valve stem is threaded and

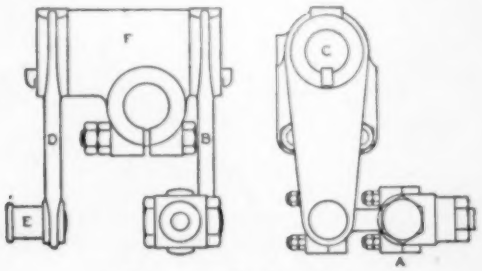


FIG. 117.—Rocker arm.

screwed tightly into an eye which connects the valve with the rocker arm by a link.

The cross-head guide bar consists of a steel bar, the upper end of which is fastened to the cylinder by two fillister head screws; the lower end is attached in the same way to a cross-bar through whose bosses pass the back columns of the engine. The cross-bar is secured to the column by set screws. Oil reaches the cross-head shoe through an oil hole extending down from the top of the guide bar sufficiently to be always covered by the shoe.

The connecting rod is a mild steel forging, forked at the upper end to receive the wrist pin. The wrist pin is of hardened steel, 1¼ inches in diameter, ground true and shrunk in the connecting rod. The lower end of the connecting rod contains the crank-pin bearing; this bearing is cast-steel shell lined with babbitt metal and is in two parts, separated by liners, and secured to the

connecting rod by two ⅝-inch through bolts and cap. When adjusted the connecting rod should move easily, without play. Wear is taken up by filing or taking out the liners.

The governor is a modification of the Rites design and is shown in Fig. 118. It is placed inside of the fly-wheel and on its outer side. The fly-wheel, *A*, is keyed to the shaft and carries the governor parts, consisting of: a weight *B*, pivoted at *C*; an eccentric *D*, with counter-weight *E*; a coiled spring *F*, taking by a knife-edge on teeth at the upper side of the weight; and a link *G*, connecting the weight to the end of the bell crank of the counter-weight.

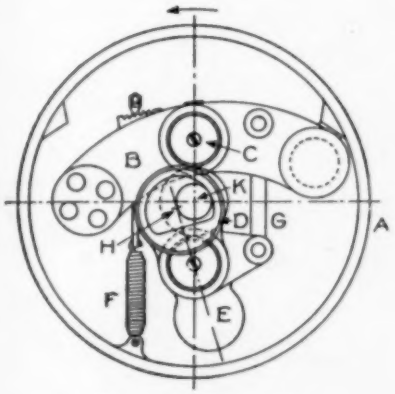


FIG. 118.—Governor.

The operation of the governor is as follows: The eccentric strap, which transmits motion from the governor to the valve, is connected to the eccentric *D*; the travel of the valve, therefore, depends upon the distance of *H* from the crank *K*. If the speed increases, the weight *B* is immediately thrown by centrifugal force toward the perimeter of *A*, decreasing the distance between *H* and *K* and shutting off steam from the cylinder; if the speed becomes too great the minimum distance between *H* and *K* is reached and practically all steam is shut off. Control of speed is effected by the tension of the spring, increasing the tension increases the speed and *vice versa*. The same effect will respectively be produced by moving the knife-edge suspension away from or towards the fulcrum *C*.

The generator, shown in Fig. 114, is of the general type explained in connection with the form G generating set, and generates 5 kilowatts, at 80 volts, and 700 r. p. m.

The series winding consists of 10½ turns of sheet copper 0.025 inch by 2.75 inches, the turns insulated from each other by 0.008-inch linen of sufficient width to overlap the edges. The weight of each coil is approximately 3.3 pounds. Resistance, cold, 0.0015 ohm. The series lead consists of copper strips 0.025 inch by 0.875 inch, two in multiple formed around a 2-way connector having a 5/16-inch hole.

In each coil of the **shunt winding** are 750 turns of No. 15 B. & S. G. single cotton-covered wire, the weight of which is about 12 pounds. Resistance, cold, 3.7 ohms. The shunt leads consist of strip copper 0.025 inch by 0.4375 inch, two in multiple, formed around a 2-way connector having a 3/16-inch hole.

The series and shunt coils are separated by two thicknesses of oiled asbestos each 0.015-inch thick, and two layers of varnished cambric each 0.0125-inch thick. The insulation between the series lead and the shunt winding consists of a pad composed of three thicknesses of varnished cambric and two of red paper arranged alternately, making a total thickness of approximately 0.06 inch. For the purpose of making a straight winding on all sides of the spool two wooden sections are placed on each side of the series lead. These are used merely as a filler and are as thick as the lead plus the insulation between the lead and the shunt winding.

The armature winding consists of 71 coils, each coil made up of 2 turns of No. 12 B. & S. G. double cotton-covered twin wire, arranged two in multiple with the ends brought out to form connections.

The brush gear is similar to that described under the form G, the brushes used being about ¾-inch thick.

The M. P. 6-2½-800 Set.

This generating set is similar to but simpler than the M. P. 6-5-700 just described. The 80-volt set complete with sheet-iron case removed is shown in Fig. 119.

The piston rod and the cross-head are in one forging of mild steel. The cross-head shoe is of gun metal, and is fastened to the

cross-head by two 5/16-inch flat-head screws which are relieved from side pressure by the webs of the shoe. The cross-head is held against the guide bar by a clamp, which is connected to the slide by four through bolts; the proper distance between the shoe and the clamp is maintained by four distance pieces through which the bolts pass. Wear is taken up by filing the ends of the distance pieces but care must be taken that the pieces are all of the

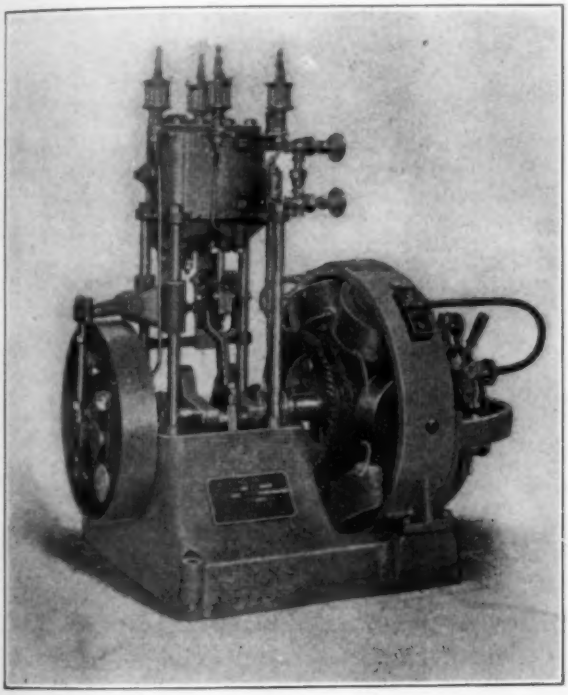


FIG. 119.—General Electric Company's M. P. 6-2½-800, generating set.

same length. The cross-head is drilled to receive the wrist-pin bearing, which is made of gun metal, and is held in place by a flange on one end of the bearing, and a key and a set screw on the under side. The bearing should be so adjusted that when the set screw is tight and the nut locked, the wrist pin will move easily without play. Oil reaches the bearing from an oil cup through a hole in the top of the bearing.

The rocker arm is a casting of elliptical cross-section, on one

end of which is a spherical steel bearing to which is attached the governor connecting rod. The rocker arm is supported by a cast-iron saddle, which is attached to the columns at the side of the engine and fixed in position by set screws. The lower end of the valve stem is threaded and screwed tightly into an eye which connects the valve with the rocker arm by double links.

The connecting rod is a mild steel forging, forked at one end to receive a wrist pin, which is of hardened steel ⅞ inch in diameter, ground true after hardening. Each end of the pin is tapped and threaded for a ¼-inch pipe tap, and contains four slots; inserting a plug in each end of the wrist pin will separate the sections of the pin formed by the slots and hold the pin in place; the pin may be removed by taking out the plugs and sliding the pin from the rod. The lower part of the connecting rod contains the crank-pin bearing, the two parts of which are bolted together by two ⅜-inch through bolts with lock nuts. The bearing is of gun metal lined with babbitt and is 1⅜ inches in diameter. When adjusted the connecting rod should move easily without play; wear is taken up by filing the caps.

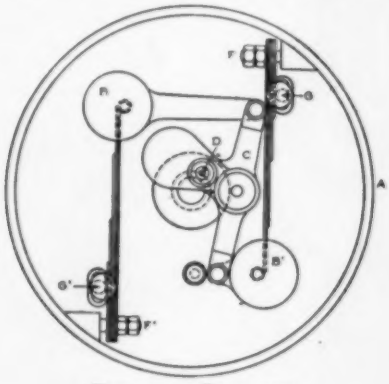


FIG. 120.—Governor.

The governor is a modification of the Rites design and is shown in Fig. 120. It is placed inside of the fly-wheel or pulley and on its upper side. The pulley *A* is keyed to the shaft and carries the governor parts, consisting of two weights *B* and *B'* connected to the opposite ends of the lever *C*, on which is the pin *D* operating the valve. The centrifugal force of the weights is opposed by the leaf springs which are connected to the fly-

wheel by the studs F and F' with double nuts, and which fulcrum on G and G'. The springs are held in place by flanges on the ends of the fulcrums.

The operation of the governor is as follows: The governor connecting rod which transmits the motion from the governor to the valve, is connected to D; the travel of the valve, therefore, depends upon the distance of D from the center of A. If the speed increases the weights B and B' are immediately thrown by centrifugal force toward the perimeter of A, decreasing the distance of D from the center of A and shutting off steam from the cylinder; when D and the center of A nearly coincide practically all steam is shut off.

The Generator.—The dynamo is of the general type as indicated in connection with the form G generating set, and generates 2½ kilowatts at 80 volts and 800 r. p. m.

The series winding consists of 22½ turns of No. 7 B. & S. G. double cotton-covered wire arranged two in multiple. The weight of each coil is approximately 3 pounds; resistance, cold, 0.0068 ohm. The series lead consists of copper strips 0.225 inch by 0.875 inch, two in multiple, to which is attached a 2-way connector.

In each coil of the **shunt winding** are 650 turns of No. 16 B. & S. G. single cotton-covered wire, the weight of which is about 7 pounds. Resistance, cold, 2.14 ohms. The shunt leads are of strip copper 0.025 inch by 0.4375 inch, two in multiple, with 2-way brass connector attached. The shunt winding is outside over the series.

The armature winding consists of 61 coils, each coil made up of 4 turns of No. 12 B. & S. G. double cotton-covered wire, arranged two in multiple, the ends brought out to form connections. The total weight of insulated wire for the winding is 20.5 pounds.

The brush gear is the same as in the 5 k. w. generator; there is but one brush per stud.

Form A—General Electric Company.

The general idea of this type of generating set is to obtain a simple, single cylinder, commercial type of generating set which is strong and light and of few parts. It has a single-cylinder

engine combining many of the advantages of the form G tandem-compound, and the dynamos have been wound for 80, 110, and 125 volts.

The type has been mainly bought for auxiliaries, for torpedo boats, or for temporary sets of gunboats, and consists essentially of two varieties. The later type has, in addition to other differences, a six-pole dynamo; the earlier, a dynamo of four poles; this distinction, however, merges as the six-pole type is four-pole in sizes of 4 k. w. and 2½ k. w. in the general classification.

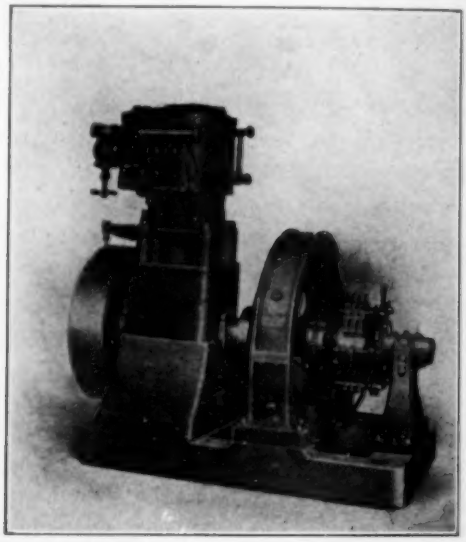


FIG. 121.—General Electric Company's Form D generating set.

When the 2½ k. w. is wound for 80 volts it is rated down to 2 k. w. The set shown in Fig. 121 is the 30 k. w. size, or M. P. 6-30-305.

The Engine.—The engine is of the vertical, inverted, reciprocating, simple, condensing and non-condensing, double-acting, direct-connected type, with a single cylinder.

The cylinder and valve-chest casting is in one with the casting carrying the rock shaft and the cross-head guide; this latter casting rests on a second which forms a casing and the base for the cross-head guide. Both castings are secured to the pedestal of the bed-plate by stud bolts passed through holes drilled

through bosses or flanges. Access to the interior of the casing is had through a door, not shown, on the back of the casing. The cylinder is cased with Russian iron, the space between the casing and the cylinder being filled with a non-conducting material.

The piston rod and cross-head are forged in one piece from machine steel; the cross-head shoes are of phosphor bronze; they have large wearing surfaces and are similar to those used for the form G, tandem-compound. Adjustment is not often required; good adjustment can be obtained by placing a thin sheet of paper or metal between the cross-head and shoe. The wrist-pin bearing is fitted with adjustable phosphor bronze boxes.

The piston is of solid cast iron with eccentric cast-iron packing rings set in two grooves; it is secured to the rod by a taper end and nut as described for preceding types.

The connecting rod is of forged machine steel in one piece, forked at the cross-head end, and having the usual stub end at the crank pin. The wrist pin is made of steel, hardened, ground true, and shrunk into the connecting rod. The crank-pin box is of cast steel lined with babbitt, with removable liners which are divided for taking up wear; the boxes can be rebabbitted.

The valve is of the solid piston type and similar to that used for the high-pressure valve in the compound engines.

The governor is of the Rites dumb-bell pattern; it is capable of changing the cut-off from ¾ to zero.

Lubrication.—All moving parts, with the exception of the governor, are lubricated by gravity, drop, sight-feed lubrication fed by a tank attached to the cylinder casing, as shown. Grease cups are used for lubricating the governor.

The Generator.—The dynamo, in all its parts, is practically the same as that used with the form G, a slight but not important change being made in the method of winding the armature.

4-Pole Type.—The 4-pole type is practically the same as the 6-pole, just described; exceptions are as follows:

Engine.—The **cylinder** and **valve-chest castings** rest on four cast columns through which the studs from the pedestal pass, thus leaving the engine open instead of enclosed. The rocker stud is secured to one of the columns. A cast casing is formed at the top of the columns for carrying the cross-head guides.

The Governor.—The weight is controlled by a spring which

is attached to the weight by a knife-edge whose position can be adjusted on a series of teeth. A counterpoise (of the valve-gear weights) carries the journal for the governor eccentric and is actuated by a short link secured to the weight and at the point of the counterpoise near the governor eccentric journal. The action is the same as the Rites patterns.

Generating Sets of the Union Iron Works.

The generating sets made by the Union Iron Works, San Francisco, California, are, in 50, 32, and 24 k. w. sizes and are, in general, of the type described in the following 50 k. w. example, which is installed in the U. S. battleship *Ohio*. A cross-section is shown in Fig. 122.

The Engine.—The engine is vertical, inverted, reciprocating, cross-compound, condensing and non-condensing, double-acting, variable-expansion in high-pressure cylinder, open frame, with accessory enclosing shields, direct-connected.

There are two **shaft bearings**; the seats are formed by semi-circular recesses machined in the bed-plate. The boxes are of composition with dove-tails cast in to secure the Parson's white metal lining; the bearing will come around to the top of the shaft and be in position to be lifted off for examination or repair.

The crank shaft has two cranks at an angle of 180°. The coupling flange is forged solid with the shaft as are also the crank pins; the latter are afterwards drilled for oil holes, the oil being supplied to the crank bearings by means of centrifugal oilers attached to the sides of the cranks.

The fly-wheel, which also contains the governor, is overhung on the part of the shaft extending beyond the outer crank-shaft bearing and at the opposite end of the shaft from the armature.

The engine frame has one column which supports both cylinders and carries the cross-head guides. The two steel stanchions serve to support the front ends of the cylinder casting and, in general, brace and strengthen the engine. A casing of sheet steel is fitted to each engine, forming an oil enclosure; it has a swinging door by which practically all the working parts of the engine can be viewed. No gaskets are provided to make the doors air-tight, as forced lubrication is not used.

The cylinder and valve chest are in one iron casting; the

center line of the valve chests and cylinders is in one line, the valve chests being at the ends. There are no bushings or liners for the bores of the cylinders. The high-pressure valve chest

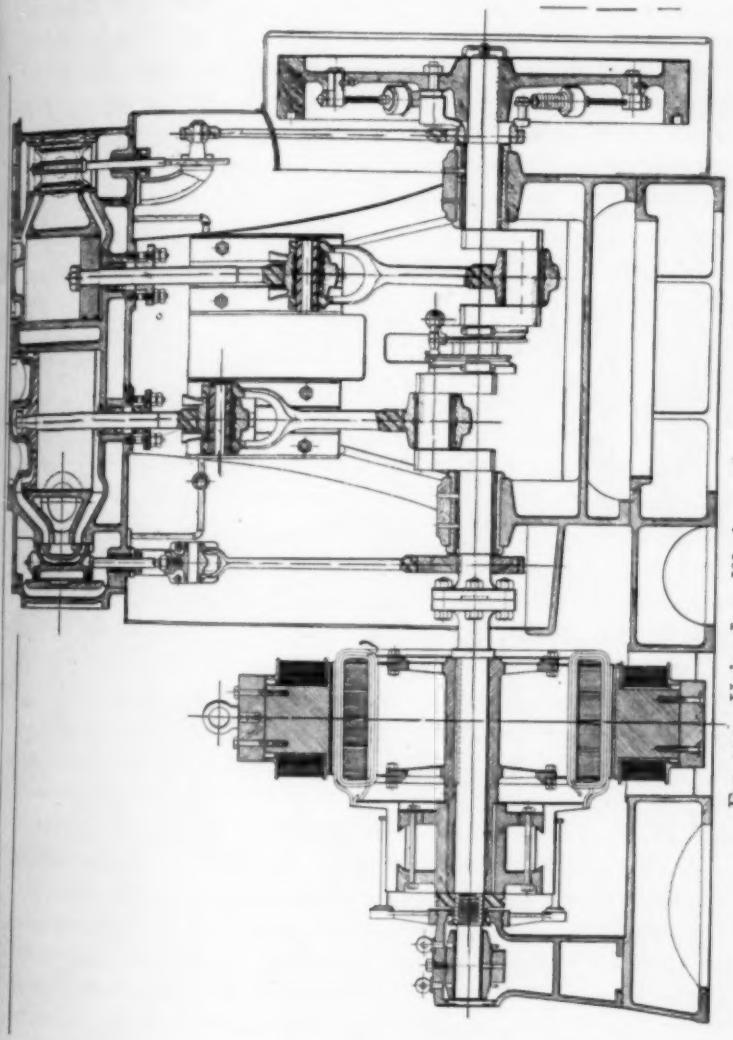


FIG. 122.—Union Iron Works 100 k. w. generating set.

has a bushing of cast iron. The lower heads are cast in place; an opening, sufficient only for the stuffing boxes, is fitted and consequently the pistons and high-pressure valve must be removed from the top.

The piston-rod and valve-rod packings are metallic, of the Katzenstein type; those on the high-pressure and low-pressure piston rods are similar and of the "sectional self-acting" form, and are shown in Fig. 123. In the lower cylinder heads is a large bushing, *A*, which forms a guide for the piston rod and a surface against which the packing rings are placed. Each ring has a serial number; the rings are placed in position in the sequence of their numbers. Rings No. 1, B, No. 3, D, and No. 5, F, are of bronze and cut in segments; these form conical surfaces forcing into place the packing rings No. 2, C, and No. 4, E, made of

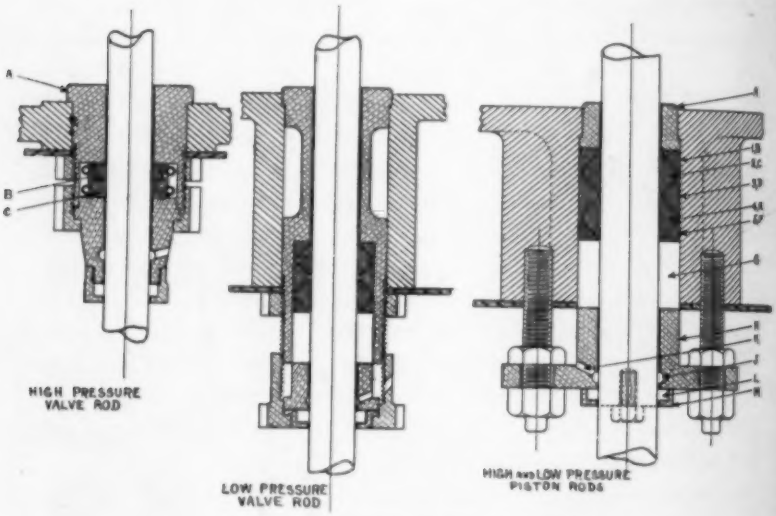


FIG. 123.—Katzenstein metallic packing.

special anti-friction metal. Rings No. 2, C, and No. 4, E, are also cut in segments, in the placing, the joints are staggered with reference to the segments of rings No. 1, B, No. 3, D, and No. 5, F. It will be noted that rings No. 1, B, and No. 3, D, and No. 5, E, do not come in contact with the rod, but leave spaces between their edges in which the water of condensation may collect. In the space, *G*, below the rings, fibrous packing is placed, increasing the elasticity of the contact of the rings and facilitating lubrication. The gland, *H*, is of bronze and guides the piston rods at their lower ends. A groove turned in at *J* is drilled with a drain hole, *K*. Below this is an auxiliary stuffing space, *L*, in

which a turn of fibrous packing is placed, and retained by the bronze gland, *M*.

The packing of the low-pressure valve rod is of similar type to that of the piston rods. The packing on the high-pressure valve rod is of the "automatic cup" form.

The steam and exhaust openings are both at the rear side.

The upper cylinder heads, high and low pressure, are separate.

The upper head of the high-pressure valve chest is a round iron casting with a hollow boss which forms a guide for the upper end of the high-pressure valve stem.

The cover of the low-pressure valve chest is a rectangular iron casting with a boss projecting outside. This boss is hollow and contains a spiral steel spring pressing a plate of composition, which rides on the back of the low-pressure valve, against the stud end and keeping the valve in its seat.

The high-pressure piston is a solid cast-iron disc with shallow recesses on each side at the nut and rod. The center is bored on a taper for the rod. In the periphery two grooves for the piston rings are cut; these rings are of cast-iron and of the spring type.

The high-pressure valve is an iron casting of the piston type, single-ported, balanced by being surrounded by steam, hollow, taking steam at neck and exhausting through the center to the ends. There are no facilities for keeping the valve tight except by replacing the valve chest liner and turning down the valve.

The low-pressure valve is an iron casting of the flat type with the supplementary port of the Allen design, giving a steam opening double that of the usual form. The travel is constant; the pressure is unbalanced. A pressure plate keeps the valve against its seat.

The lubrication of the engine is by drip feed and oil cups. The main supply is from a tank on the forward side of the cylinders, from which tubes lead to the high-pressure eccentric, outer crank shaft bearing, high-pressure cross-head slide, high-pressure cross-head (two), high-pressure crank pin, low-pressure cross-head (two), low-pressure cross-head slide, inner crank-shaft bearing, and low-pressure eccentric strap. The tubes for the high-pressure and low-pressure cranks drip into bronze rings which are attached to the inner ends of the cranks. The oil is thrown by centrifugal action to the outer edge of the recess in the

rings and through holes in the pins to the bearing surfaces. The tubes for the eccentric straps drop into cups at the forked end of the eccentric rods; the oil is led through a tube alongside of the rod to the upper half of the eccentric strap.

A brass **oil guard,** attached to the lower end of the low-pressure valve chest and the engine bed-plate, prevents any oil or drip from the engine from reaching the generator; another guard of sheet steel shields the fly-wheel from oil and the drip of the drains.

A system of **drain piping** terminating in a common outlet is fitted to the high-pressure and low-pressure valve chests and to both ends of the high-pressure and low-pressure cylinders.

Relief vales are fitted to each end of the high-pressure and low-pressure cylinders, on the rear side, and are independent of the drain piping.

Indicator Gear.—On the centrifugal cup of the crank shaft, nearest the center line of the engine, eccentrics are embodied for surfaces on which rollers, on the levers of the indicator motion, are kept in contact by spiral springs at the pivot of the levers. These pivots are mounted on lugs at the back of the engine frame. A detent and lever admit of lifting the lever from contact with the slide. The short ends of the levers have a hole to which the cords are attached. The indicators are on the rear side of the cylinders.

The governor (Fig. 124) is of the centrifugal shaft type, swinging the high-pressure eccentric in an arc, and by altering the angular advance and throw produces those changes in admission, expansion, exhaust, and compression, which are required for the varying conditions of load. The parts of the governor are mounted on the engine side (inside) of the fly-wheel, and consist of a double set of weights, arms, springs, stops, and adjustments. Being double, the governor as a whole is balanced at all times; both sets are connected by a link, attached to the weight arms, and to the kite-shaped casting of which the high-pressure eccentric forms a part. The adjustments are made by varying the position of the weights on the arms, the spring tension, the position of the outer attachment of the springs, and the throw of the arms.

To increase the speed the weight may be shifted away from

the spring, or decreased in weight; or the spring may have less tension, or be moved at the outer end towards the rim. For close regulation the outer point of suspension of the springs should be moved towards the rim; this will decrease the speed; to compensate for this either the tension may be increased or the weights be moved farther from the springs. Too close regulation tends to cause hunting, but can be overcome by moving the outer point of suspension of the springs away from the rim. To compensate for the increase of speed either decrease the tension or move the weights towards the springs.

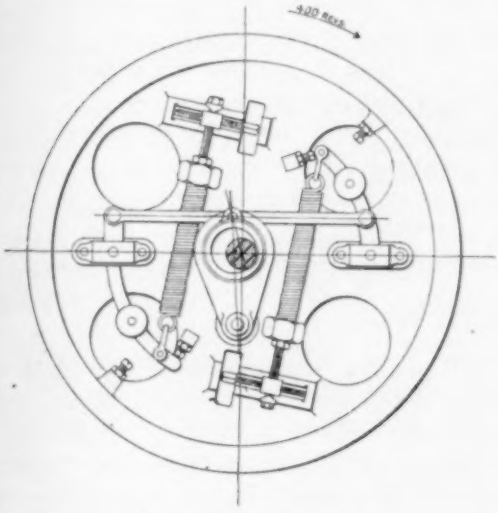


FIG. 124.—Governor.

The Generator (Fig. 122).—**The field frame** is of circular shape and rectangular section, horizontally divided, and having machined surfaces for cores. The two halves are secured together with lugs and bolts and the pole cores are secured in position by means of bolts passing through the frame.

The pole cores are fitted with separable, cast-steel shoes, secured in place with screw bolts.

The spools carrying the **field winding** are mounted on the pole cores. They are made of 1/16-inch asbestos and two layers of varnished bristol board. After this insulation is in position the series field conductor is wound, consisting of 4½ turns per

spool of two No. 13 Brown and Sharp gauge copper strips, in parallel; each strip is 5 inches wide. The insulation between the turns of the series conductor consists of 26-mil. (8-oz.) oiled duck. On top of the series conductor an insulation consisting of oiled bristol board and flexible mica is next placed and the shunt is then wound. This winding consists of 516 turns per spool of No. 9 B. & S. gauge, single cotton-covered magnet wire, the insulation of which is soaked in an insulating varnish prior to winding. The finished winding is varnished with a black insulating compound.

The armature is of the Pacinnoti-Gramme type.

The spider is made of cast iron and has six arms. It has an extension upon which the commutator is mounted and secured in place by a steel feather 10½ inches long. A lock nut setting up against the end of the spider and commutator clamps the former securely in place. The lock nut also secures the commutator in place against a shoulder on the extension of the spider on which it is mounted.

The armature **core-discs** are made in sections, each section subtending an angle of 60 degrees. Six sections are required to form a complete disc. The discs are mounted on the driving rods so that the joints are staggered 30 degrees apart, about 570 complete discs being required for the completed core. The discs are insulated from each other by thin coatings of japan.

The armature body has three cast brass ventilators spaced about 3 inches apart. They extend entirely around the armature and consist each of a ring made in web-bed form with 108 projections on each side which separate the discs sufficiently to permit of the formation of the same number of ventilating openings. The armature has two end flanges; the discs being insulated therefrom by discs of ⅛-inch fiber, slotted similarly to the core-discs.

There are 108 slots in the armature. Each slot is 1 1/16-inch deep and 7/16-inch wide; tapering to the full width of 7/16 inch for the first 5/32 inch of the total depth. For the remainder of its depth the slot forms a regular parallelogram. A T-shaped tooth is thus formed, the overhang of which serves to retain in place the hardwood wedge which, in turn, holds the armature conductor in position in the slot.

The armature winding consists of three turns per slot, five in

parallel, of .040 by .340 double cotton-covered copper of rectangular section. Before winding the conductors in place they are treated with an insulating varnish with which the insulation is thoroughly soaked.

The system of armature winding employed is that commonly known as the "simplex ring," having parallel, singly-reentrant grouping of conductors. The armature is hand-wound and the connecting pitch is one bar. No equalizer rings are used in this type of armature. The ends of the coils are soldered directly into the commutator bar lugs, there are 108 connections, the same as the number of coils and lugs.

The commutator consists of 108 cold-rolled copper bars with riveted and soldered lugs. No cross connections are employed.

There are the same number of **sets of brushes** as there are poles for the magnetic circuit, viz.: six; three positive and three negative. The brushes are of carbon, 1 inch by 2 inches by 4 inches in size. As the bars are each .536-inch wide the brushes, which are 1-inch thick, do not quite cover two bars. They feed in arcs of 4¾-inch radius.

The brush gear is mounted on a rocker arm which is, in turn mounted upon an extension on the pillow block. The rocker arm has six arms, each of which carries a brush stud upon which six brush holders are mounted; the total number of holders being 36. The brush holder cables, or leads, consist each of three "extra flexible" cables of about 300,000 circular mils cross-section each.

Each generator is provided with a **headboard** carrying a circuit breaker of the "ITE," laminated wedge, edgewise, double-pole type.

Generating Sets of the B. F. Sturtevant Company.

Until recently the generating sets supplied by this company were of the 5 k. w. size for torpedo-boat destroyers. The later designs include 100 k. w. and 50 k. w. sizes.

The Engine.—A cross-sectional view of the 100 k. w. engine is shown in Fig. 125; it has also been installed in conjunction with dynamos of other than the Sturtevant manufacture.

The cylinders are 10 inches and 18 inches diameter by 10-inch stroke.

The steam pressure is 150 pounds normal, the engine being designed to work at a normal vacuum of 25 inches or on atmospheric exhaust.

The construction of the engine embodies the same general features which contribute to the strength, durability, and satisfactory operation of the form H of the General Electric Com-

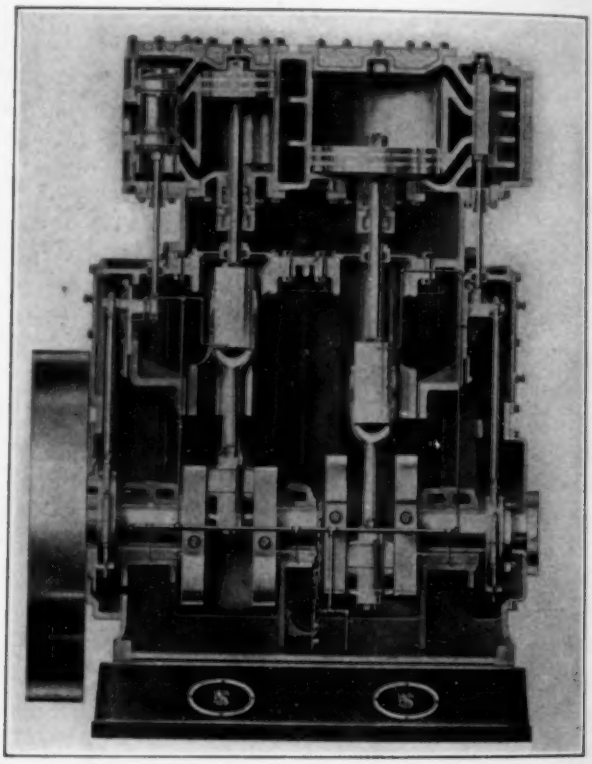


FIG. 125.—B. F. Sturtevant Company's Engine, 100 k. w.

pany already described in detail. The salient features of the particular design are noted as follows:

The cylinders and valve chests are cast with an annular recess into which non-conducting material is packed to prevent radiation of heat from the heads.

The high-pressure piston valve is fitted with two snap rings and one guide ring on each end.

The pressure plate of the **low-pressure valve** is not self-adjusting.

The high and low-pressure cross-head shoes are double-surfaced, and curved to fit against the inner bored surfaces of the cross-head guide. This latter is bored circularly with a long opening on the inner sides where most accessible and a smaller opening on the other sides; a flanged ring at the upper end is bolted to the underside of the guard plate and are removable from below as required for truing up.

FIG. 126.—Outside view of governor.

The high-pressure eccentric is mounted on a pin extending through the fly and governor wheel; the arrangement resembling the device used in the Union Iron Works engine.

The upper halves of the **main bearings** are cast hollow.

The forced lubrication system is similar in general details to systems already described; the pipe connections are shown in Fig. 125.

The governor is of the Rites "dumb-bell" type and is mounted on the outside of the fly-wheel as shown in Fig. 126. This particular variety of weight in governors of the type is discussed in the Notes on Generating Sets farther on in this text, and from which it only differs in that an eccentric is actuated by a pin

through the fly-wheel to the dumb-bell weight instead of by a connecting rod to a rocker arm as in the form G, General Electric Company; this change in device permits the use of a weight at greater radius to actuate an eccentric, rod, and strap within the enclosed engine casing, and the spring is more accessible for adjustment. The outside weight design has the advantage of accessibility, but has the disadvantage of less thorough lubrication of its journal.

The Generator.—The dynamo is, in general details, much the same as the 100 k. w. already described, and is of the 8-pole construction.

The pole shoes are separable from the field cores, with the **series coil** next to the shoes.

The shunt coil is wound on a single spool with a dividing air space running the length of the coil at the center of the winding.

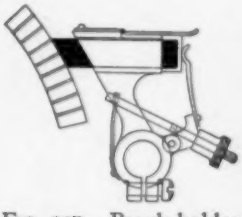


FIG. 127.—Brush-holder.

The armature is of the multiple-wound, drum-wound, slotted-core type.

The brush holder is shown in Fig. 127, and is a characteristic feature of Sturtevant dynamos and motors; the brush is pressed down by a phosphor bronze spring, while an extra spring action is given to the adjusting screw by securing its end in another spring attached to the bottom of the brush holder.

The brushes are wide in comparison with their width, requiring fewer brushes per stud. When set, the brushes on one stud stagger with the next succeeding, to give even wear to the commutator surface.

Generating Set for Torpedo-Boat Destroyers.

The Sturtevant design for a 25 k. w. generating set is shown in Fig. 128 and differs mainly in the governor; for torpedo-boat use the set is of 5 k. w. capacity, generating 80 volts at 62.5 amperes and 500 r. p. m.

The overall dimensions in inches are: length, 49⅛; width, 27⅞; height, 27½. The weight is 1275 pounds.

The Engine.—The engine is of the vertical, simple, double, enclosed type. The designed steam pressure is 100 pounds rated, but is capable of a variation from 120 to 80 pounds, with a

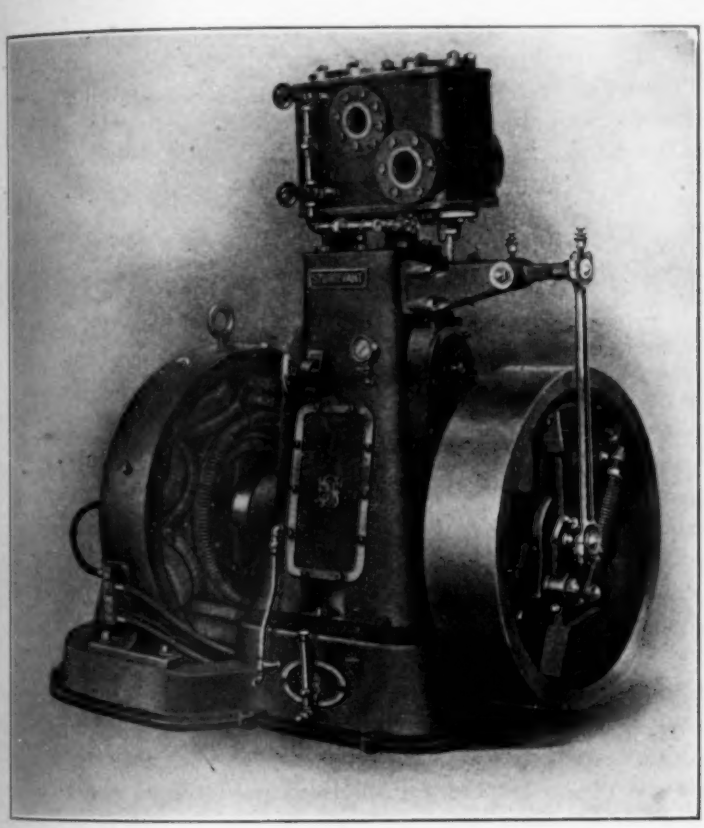


FIG. 128.—Sturtevant Company's 25 k. w. generating set.

vacuum of 25 inches or atmospheric exhaust. The cylinder dimensions are 3½-inch by 3½-inch bore with 2½-inch stroke. The steam and exhaust pipes are both 1½ inches in diameter.

The governor, shown in Fig. 129, is of the Shepherd design which, while having points of similarity to the Rites' type, embodies some especial features of construction and action. The

governor wheel *A* is the fly-wheel of the engine; the eccentric *B* to which the eccentric rod and strap are attached, is shown in the cross-sectional view. The eccentric is carried by the weight arm *C* to which it is attached by two fillister head screws. The weight arm is attached to the governor wheel off its center, so that the eccentric has a pivotal motion which affects the travel of the valve and also the lead of the valve at different points of cut-off. The main weight *D* is cast on the weight arm at the left-hand end; the right-hand end is bored for a cross pin which connects with the auxiliary weight *E*. The governor spring *F* is attached to the auxiliary weight by a hooked end which encircles a pin in the weight; there are three adjusting holes in the

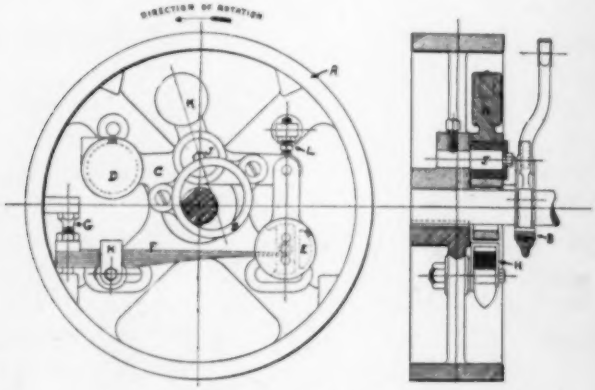


FIG. 129.—Governor.

weight for this pin. The spring is attached to the governor wheel by a stud *G*. A nut on the upper side of the spring affords means of adjusting the tension to balance the weights for the required speed. The direction of the movement of the outer end of the spring under compression is such as to describe substantially the same arc as the main weight *D*. The position of the fulcrum of the spring *H* is adjustable, and the strength of the spring, that is, the ratio of the increase in tension, is so varied as to practically balance the weights at all positions of their movement. The auxiliary weight *E* is pivoted to the end of the weight arm, rather than made rigid with it, in order that the centrifugal force acting upon the arm may be added to the force acting on the main weight. If it were rigid and had a

pivotal action around the stud *J* the effect would tend to oppose the force acting on the main weight. The link attaching the auxiliary weight *E* is of such a length as to bring the auxiliary weight diametrically opposite the main weight *D* that they may balance each other; the arms of the weight arm *C* are also balanced in the same way. The weight of the eccentric *B* is balanced by the weight *K*. The stop at *L* prevents the inside of the eccentric from striking the shaft and limits the maximum travel of the valve.

The two weights, *D* and *E*, are hollow and partly filled with lead shot. The speed can be changed by adding or removing shot; add shot to both to *decrease* speed; remove shot from both to *increase* speed. A slight change in speed can also be made by changing the spring tension at *G*, but much change will affect the regulation. A great change in speed, by changing the weight of shot in the hollow weights *D* and *E*, will sometimes necessitate a readjustment of the spring to maintain the same degree of regulation; this is due to the fact that adding or deducting weight at one point alters the center of gyration of the system.

If the governor does not keep the desired speed under load, the spring tension should be increased at *G*. Increasing the spring tension will increase the speed; to counteract this, either add shot to the weights *D* and *E* or move the spring fulcrum *farther* away from the center of the wheel. The spring tension can be changed by the nut on the adjusting stud *G;* also by changing the pin to another hole in the balance weight *E*. If the engine should run faster under no load than with load, and to a greater speed than is desired, *decrease* the spring tension and regain the speed thereby lost by deducting shot, or by moving the spring fulcrum *H toward* the center of the wheel.

The Generator.—The dynamo (Fig. 128) is designated as the special 1-100-M. P.-8 type. The voltage is 80 at 500 r. p. m., with an output of 5 k. w.

There are eight poles.

The field coils are made up without spools. The series coil is inside and consists of 11 turns of copper strip, 2½ inches by 0.024 inch. The shunt coils are wound outside of the series and consist of 12½ pounds each of No. 15 B. & S. G., D. C. C. C. wire, Over the windings are four thicknesses of tape.

To ensure water-proofing, the coils, after winding, are soaked one hour in an insulating varnish, then drained one hour and baked for 24 hours at 120° to 180° F.; then the tape is wrapped on and varnished.

The Forbes' Engine.

W. D. Forbes & Company are engine builders and do not manufacture generators; engines of the type have been received in combination with Crocker-Wheeler, Bullock, and Thresher dynamos.

The engine design has several individual features differing from types heretofore described.

The 100 k. w. size, shown in cross-section in Fig. 130, is designed for 150 pounds of steam, at 25 inches vacuum or for atmospheric exhaust. The cylinders are 10 inches and 20 inches and 10-inch stroke.

The enclosing frame is comparatively light, and is intended more as an oil guard than for engine construction, the cylinders and valve chests being supported by four stanchions within the frame, set up in bed-plate by nuts and extending up through the top of the casing where they are secured by nuts and washer; these stanchions carry the cross-head guides for the piston rods and the rock-shaft bearings. The enclosing frame supports the valve-stem guides.

The piston-rod packings are of the Katzenstein type (Fig. 123).

The piston rod and cross-head are in one forging and in one with the cross-head is the cross-head side having a T-shaped section in its extension, from the cross-head to top of the "T" running under the guides; these latter embrace the top of the "T" and control the cross-head motion to the center line. Wear is taken up by liners back of the guide face.

The connecting rod is forked, securing with the ordinary stub end, and is comparatively short.

The high-pressure valve is between the cylinders and is actuated by an eccentric secured to the shaft.

The high-pressure and low-pressure cylinders are reversed as compared with most other constructions, *the high-pressure cylinder being next to the dynamo. The governor controls the*

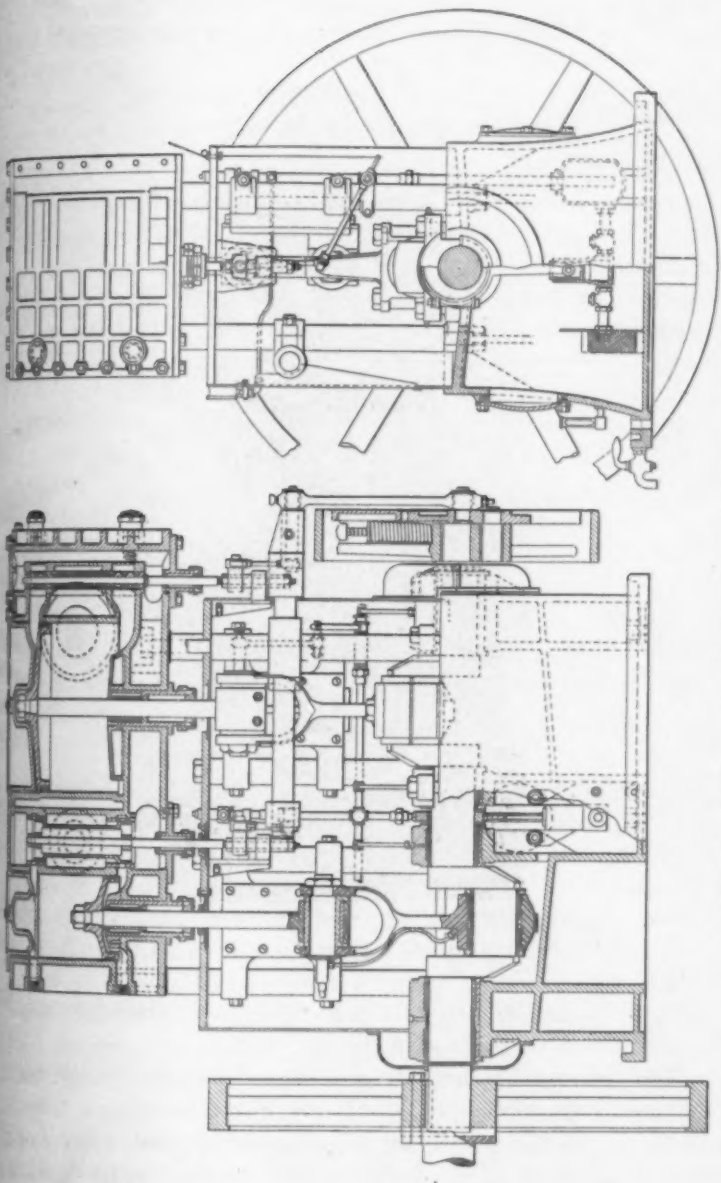


FIG. 130.—Cross-section W. D. Forbes & Company Engine, 100 k. w.

L. P. valve in this engine and not the H. P. valve as is usually the case.

The rock-shaft extends through the casing from the governor end and is supported by journals secured to the stanchions. It receives its motion through a governor connecting rod and communicates its motion to a link on the valve stem of the low-pressure valve, the stem working in a square box guide on the outside of the casing.

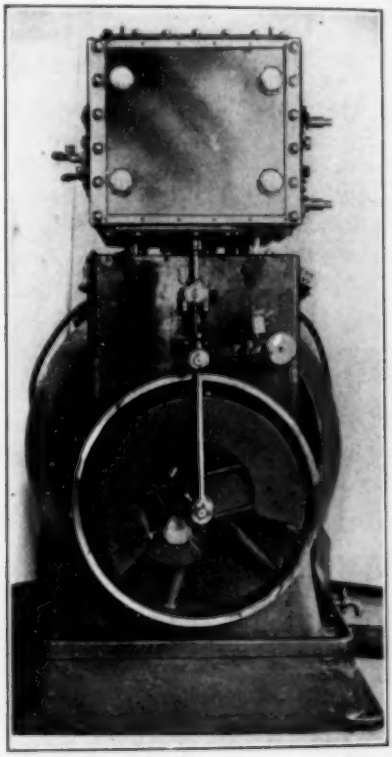


FIG. 131.—Governor, 100 k. w. engine.

The fly-wheel is between the engine and the dynamo and is assembled on the engine shaft; the hub is used as a flange to attach to the flange of the armature shaft, the radial driving keys being fitted in slot-ways in both the fly-wheel hub and the coupling flanges; the crank-shaft bearing next the dynamo is

therefore made long to support the overhung weight of the fly-wheel, the weight of both fly-wheel and armature being supported by this bearing and the pillow block bearing at the end of the armature shaft.

Governor.—There are two types of governor used with the Forbes' engine, both constructed on the Rites' design.

The type used with the 100 k. w. engine is shown in Fig. 131. The weight embraces the greater part of a circle and is attached to a cross-arm pivoted as shown. The spring controls the centrifugal motion of the weight in the usual way. The fulcrum of the spring is adjustable in a slot. The action and adjustments are the same as for other governors built on the Rites' design.

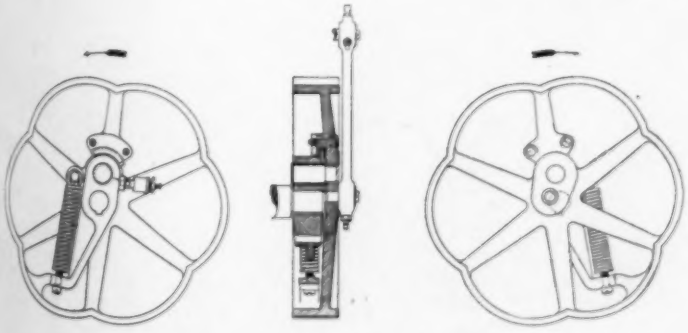


FIG. 132.—Governor for 24 k. w. and below.

The type used with smaller engine designs is shown in Fig. 132. It is a modification of the Corliss type of the Rites' design. The governor standing part is an iron casting keyed to the shaft. At one side of the shaft is an extension which is bushed to form the bearing for a stud extending from the governor weight, and in the opposite direction is an extension which forms the outer point of attachment of the governor spring. The governor weight is a cam-shaped iron casting. The parts of the wheel face between the arms (or spokes) are arched out to reduce shrinkage strains, and to reduce, by a multiplied fluttering, the optical effect of the governor's eccentric rotation. To one of the six arms is attached a stud which forms the inner point of attachment of the governor spring. The eccentric pin is of machine steel and extends outwardly from the hub of the governor weight.

The governor weight retaining plate is a composition casting which is secured by two fillister head machine screws to two extensions of one of the governor arms and engages with a projection at the governor standing part to keep the governor in position longitudinally on the stud. When any "sticking" occurs with this type of governor, it will usually be found in a too tight setting up of the cap nut that secures the weight.

The outboard, or dynamo end, bearing, is a straight sleeve bearing.

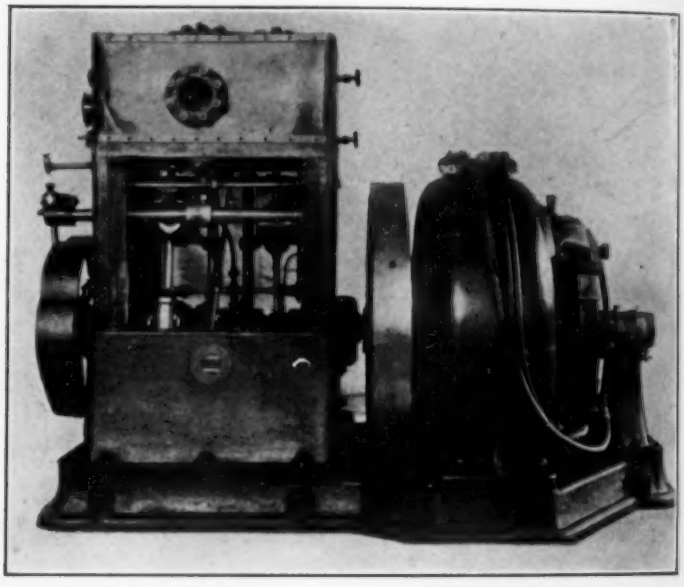


FIG. 133.—Crocker-Wheeler 16 k. w. generator (Forbes Engine).

[NOTE 22.—The Forbes' Company supply the bed-plate and pillow block bearing for combinations for which they furnish the engine. This rule is general where the dynamo and engine are not constructed by the same corporation.]

The Crocker-Wheeler Generator.

A 16 k. w. generating set combining the Forbes' engine and Crocker-Wheeler dynamo is shown in Fig. 133; the same combination has been supplied in the 100 k. w. size.

The generator shown is of the modern form of multi-polar-field, drum-wound, slotted-core armature.

The 210 **core discs** are of .022-inch sheet steel with sixteen 3/64-inch discs at the ends of the core divisions; 50 paper discs .003-inch thick separate the discs to reduce Foucault currents.

The armature winding consists of 76 coils of alternately 2-turn and 3-turn coils in 76 slots.

The conductor is one No. 6 double cotton-covered, with 10 wires to each slot.

The connections are six-circuit to 152 commutator bars.

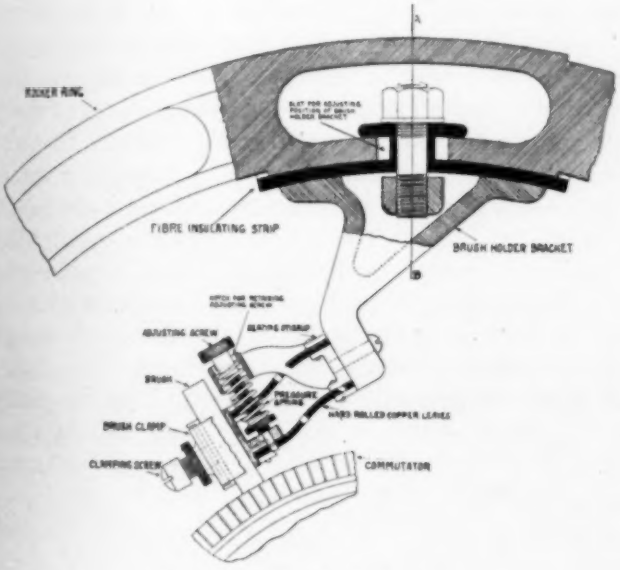


FIG. 134.—Brush rigging.

The insulation on the coil is 1-inch linen tape, and in the slots two .012-inch press-board and two .008-inch Empire cloth.

The bands are ½-inch wide and of No. 20 phosphor bronze wire.

The commutator bars are of rolled copper separated by .035-inch micanite. The tails of the bars are of two copper strips riveted in a slot in the end of the bar and also riveted together.

The brush-holders, shown in Fig. 134, are of the radial type, the tension being provided by a steel-wire spring in compression. The brush-holders are bolted to brackets which extend radially inward from the cast-iron rocker ring. Slots in the rocker ring

admit of varying the angle between the various brushes to adapt the brush position to any variations in magnetic balance of the armature circuits. The holder is attached to the rocker ring through two laminated flat springs of .05-inch copper.

The brushes are of carbon and are clamped in place. They may be lifted from contact with the commutator by raising the entire brush-holder until the shoulder of the adjusting screw is outside of the hole, and then pushing the adjusting screw back until the shoulder overlaps the edge.

The field frame is circular in shape and divided at the center. At the points of division flanges are turned inwardly to take the two bolts in each side. The edges of the frame are turned in towards the center slightly, adding to the stiffness of the frame and affording extra protection to the field coils.

The field spools are tin cylinders surrounding the cores; they have a brass head at the armature end and a glavanized iron end toward the frame. The insulation of the cylinder is "P" and "B" paper, and of the heads a washer of 3/32-inch fiber.

The winding of each spool consists of 750 turns of No. 10 D. C. C. for the shunt, and 8½ turns of ¾-inch by .015-inch copper strip, 13 in multiple for the series.

The shunt on the series coil consists of, approximately, 24 loops of German silver, 4 in parallel, ⅞-inch wide, which are to be adjusted to suit the characteristics of the individual generator.

CHAPTER VII.

MOTORS.

General Considerations as to Types in Use.

In 1871 the electrical energy supplied to a ship consisted of one or two small Farmer's series dynamos, whose armature was revolved by a hand crank and whose output did not exceed 100 or 150 watts, an amount of energy which is now-a-days consumed by a single 32 c. p. lamp. The *Alabama* class and the *Iowa* are supplied with an output of 96,000 watts; the *Brooklyn*, with 150,000 watts; the *Kearsarge*, with 350,000 watts; and the *Connecticut*, with 400,000 watts, or 711 horsepower at 33 per cent overload.

The growing output is mainly due to the increasing demands for electrical drive, which consumes fully 80 per cent of the total power allotted in the generators. The ease and facility of maintaining and repairing electric leads; the objectionable heat of long lines of steam piping; the annoying leaks of hydraulic apparatus; the bulk and weight of pneumatic machines; the avoidance of the complications incident to several different systems of drive within the same ship; the injurious or distracting effect on the personnel of a compartment in case of accident to, or the cutting of, pipe lines in battle; the satisfactory efficiency and economy of electric drive as compared with other systems, and its flexible adaptability to power use in general, have practically caused the adoption of electricity as the actuating agent for all power purposes outside of the engine and fire-rooms and their immediate connections; in these compartments steam drive is still in general use. There are two exceptions as yet to the general application of electric drive for ship auxiliaries as compared with steam; they are for actuating the steering engine and the capstan or windlass. The peculiar shocks and stresses to which the rudder and anchor hoist are often subjected have not thus far been demonstrated to be as readily controllable by electrical methods, as by the cushioning effect of steam or air; electrical

Service.	No.	Make.	Type.	Form.	Winding.	H. P.	Volts.	Amperes.	Controller.	No. of Rheostats.	Type of Rheostat.	Circuit Breaker and Brake.
MOTORS FOR MOTOR GENERATORS.												
Turret Turning, 12-in.....	2	Gen. Elec. Co.	C. B. G. 4-25-100	B	Compound	35	125	200	.....	.....	.....	.....
Turret Turning, 8-in.... ..	4	Gen. Elec. Co.	C. B. G. 4-25-100	B	Compound	20	125	120	.....	.....	.....	....
Gun Elevating, 12 in.....	4	Crocker-Wheeler.	G. E...	.....	Shunt	8	125	43	....	.....	....	.....
Gun Elevating, 8-in.....	8	Northern Elec. Co.	.....	.....	Shunt	5	125	23.1	.....	.....	.....	.....
Wireless Telegraph.....	1	Crocker-Wheeler.	.....	.....	Compound	5	125	37.50	.....	.....	....	.....
Telephone.....	1	Holtzer-Cabot Co.	E.	.....	Shunt	¼	125	2.35	....	.....	....	....
MOTOR FOR DYNAMOTOR.												
Interior Communication...	1	Crocker-Wheeler.	D. M....	.....	Shunt	.....	125-20	4	....	.....	.....	....
MOTORS.												
Turret Turning, 12-in.....	4	Gen. Elec. Co.	C. B.-25	G	Shunt	35	125	240	Gen. Elec. Co. P-10-A.	4	Gen. Elec. Co. Special.	Brake Type C. Circuit Breaker, Gen. Elec. Co., Type M. Q.
Turret Turning, 8-in.....	8	Gen. Elec. Co.	C. B.-32	A-1 ..	Shunt	15	125	105	Gen. Elec. Co. P-10-A.	8	Gen. Elec. Co. Special.	Brake Type C. Circuit Breaker, Gen. Elec. Co., Type M. Q.
Ammunition Hoists, 12-in..	4	Gen. Elec. Co.	C. B.-25	B-9 ..	Shunt	55	120	390	Gen. Elec. Co. B-44-A.	36	Gen. Elec. Co. P. R. Form 30.	Brake E. D. 111. Brake Rheostat P. A. Form A.
Ammunition Hoists, 8-in..	8	Gen. Elec. Co.	C. B.-38	B .. .	Shunt	17	120	101	Gen. Elec. Co. B-28-E.	24	Gen. Elec. Co. P. R. Form 30.	Brake E. D. 111. Brake Rheostat Type E. C.
Am'tion Hoists, Chain, 7-in.	12	Gen. Elec. Co.	C. B.-27	F-6 ..	Shunt	5	125	33	.....	.....	.....	.....
Am'tion Hoists, Chain, 5-in.	14	Gen. Elec. Co.	C. B.-27	F-3 ..	Shunt	3	125	22	.....	.....	.....	....

Ammunition Hoists, 8-in..	8	Gen. Elec. Co.	C. B.-38	B .. .	Shunt	17	120	101	Gen. Elec. Co. B-28-E.	24	Gen. Elec. Co. P. R. Form 20.	Brake E. D. 111. Brake Rheostat Type E. C.
Am'tion Hoists, Chain, 7-in.	12	Gen. Elec. Co.	C. B.-27	F-3 ..	Shunt	3	125	23	.....	.....	.....	.....
Am'tion Hoists, Chain, 3-in.	14	Gen. Elec. Co.	C. B.-27	F-3 ..	Shunt	3	125	23	.....	.....	.....	.....
Ammunition Hoists, Whip.	6	Gen. Elec. Co.	C. B.-33	B	Shunt	3	125	24	Gen. Elec. Co. B-34-B.	6	Gen. Elec. Co. P. C.	Circuit Breaker, Gen. Elec. Co., Type M. Q.—30/60
Ammunition Conveyor.....	4	Gen. Elec. Co.	C. B.-27	B	Shunt	4	125	30	.....	.....	.....	.....
Gun Elevating, 12-in.....	4	Gen. Elec. Co.	C. B.-17	A-25..	Shunt	8	125	44	Gen. Elec. Co. Special Cont. Rheostat.	4	.....	.....
Gun Elevating, 8-in..... ..	8	Gen. Elec. Co.	C. B.-15	K-18 .	Shunt	5	125	28	Gen. Elec. Co. Special Cont. Rheostat.	8	.....	.....
Gun Ramming, 12-in.....	4	Gen. Elec. Co.	C. B.-27	S-22 ..	Series	10	120	74	Gen. Elec. Co. R-95-B.	4	Gen. Elec. Co. P. C.	Circuit Breaker, Gen. Elec. Co., M. Q.
Gun Ramming, 8-in.....	8	Gen. Elec. Co.	C. B.-29	A-1 ..	Series	3½	120	21	Gen. Elec. Co. R 95-A.	8	Gen. Elec. Co. P. C.	Circuit Breaker, Gen. Elec. Co.. M. Q.
Boat Crane, Hoisting.....	2	Gen. Elec. Co.	C. B.-24	C	Series	50	125	340	Gen. Elec. Co. Hoisting and Turning.	16	Gen. Elec. Co. P. R.	Brake E. D. 108. Gen. Elec. Co., Circuit Breaker, Form Q, Amp. 500-1000.
Boat Crane, Rotating... ...	2	Gen. Elec. Co.	C. B.-25	G	Series	30	125	210	Combined R-62-A.	12	Gen. Elec. Co, P. R.	Gen. Elec. Co. Circuit Breaker, Form Q, Amp. 500.
Deck Winches..... ...	6	Thresher Elec. Co.	M	.....	Compound	25	125	175	Thresher Elec. Co. W.P. Drum.	6	Cast Iron Grid Type.	Circuit Breaker. Cutter Co.
Power Doors and Hatches.	47	Long Arm Co.	.....	.....	Compound	1	125	8.8	Long Arm Co. Special.	.....	....	.....

Service.	No.	Make.	Type.	Form.	Winding.	H. P.	Volts.	Amperes.	Controller.	No. of Rheostats.	Type of Rheostat.	Circuit Breaker and Brake.
MOTORS FOR VENTILATION.												
80-in. Steel-Plate Fan	2	Holtzer-Cabot Co.	E.-20		Shunt	12	125	81				
60-in. " "	5	Holtzer-Cabot Co.	E.-7½		Shunt	6.3	125	44				
55-in. " "	2	Holtzer-Cabot Co.	E.-7½		Shunt	5.8	125	40				
50-in. " "	2	Holtzer-Cabot Co.	E.-7½		Shunt	4.6	125	32				
45-in. " "	6	Holtzer-Cabot Co.	E.-5		Shunt	3.75	125	27				
40-in. " "	2	Holtzer-Cabot Co.	E.-3		Shunt	2.6	125	18				
35-in. " "	1	Holtzer-Cabot Co.	E.-3		Shunt	2.2	125	16.1				
30-in. " "	1	Holtzer-Cabot Co.	E.-2		Shunt	1.65	125	12.1				
No. 6 Monogram Exhaust Fan.	2	Holtzer-Cabot Co.	E.-3		Shunt	2.7	125	20.5				
No. 4 " " "	8	Holtzer-Cabot Co.	E.-2		Shunt	1.1	125	8.2				
No. 2 " " "	2	Holtzer-Cabot Co.	E.-1		Shunt	.75	125	6.				
¼-H. P. Portable Fan	6 2	Sturtevant Holtzer-Cabot Co.	R. B M.	C	Shunt	1/4	125	1.6 2.33				
⅛-H. P. Fan	8	Western Elec. Co.			Shunt	1/6	125	1.				
1/12-H. P. Fan	57	Western Elec. Co.			Shunt	1/12	125	.5				
SELF-CONTAINED MOTORS ON WORKSHOP TOOLS.												
26-in. x 42-in. Extension Gap	1	Westinghouse	No. 4.		Shunt	7½	125	91.5				

1/8-H. P. Fan	57	Western Elec. Co.			Shunt	1/12	125	.5				

SELF-CONTAINED MOTORS ON WORKSHOP TOOLS.

36-in. x 48-in. Extension Gap Lathe.	1	Westinghouse Elec. & Mfg. Co.	No. 4. Type S.		Shunt	7½	125	61.5				
16-in. Shaper	1	Westinghouse Elec. & Mfg. Co.	No. 6. Type S.		Shunt	5	125	36.5				
Universal Milling Machine.	1	Westinghouse Elec. & Mfg. Co.	No. 2. Type S.		Shunt	2	125	17				
Emery Grinder	1	Stow Mfg. Co., Binghamton, N.Y.			Shunt	2	125	17				
22½-in. Drill Press	1	J. Clark, Jr., & Co.			Shunt	1	125	12				
14-in. Lathe	1	Westinghouse Elec. & Mfg. Co.	No. 2. Type S.		Shunt	1	125	9.2				
Sensitive Drill Press	1	J. Clark, Jr., & Co.			Shunt	1/4	125	2				

MISCELLANEOUS MOTORS.

Dough Mixer	1	Gen. Elec. Co.	2-3	A	Shunt	Open 3 H. P. Closed 2½ "	125	Open 21.5 Closed 18.4				
Dish Washer	1	Robbins & Meyer Co.			Shunt	3/4	125	6				
Meat Chopper	1	Gen. Elec. Co.	C.A.-2	B	Shunt	3/4	125	6.16				
Potato Peeler	1	Gen. Elec. Co.	C.Q.-1		Shunt	1	125					
Torpedo Air-Compressor	2	Northern Electric Co.			Shunt	80	125	52.5				
Pumps—Fresh Water	2	Gen. Elec. Co.	C. E.-2		Shunt	2	125	14.5				
Pumps—Sanitary	2	Holtzer-Cabot Co.	E.-5		Shunt	3	125	21.5				
Laundry	1	Gen. Elec. Co.			Shunt	8	125	58.5				

means of handling the valves are sometimes employed. The engines for the two types of appliances, unfortunately, require long lines of piping which must be led through compartments where the heat is inconvenient and undesirable.

The number and types of direct-current motors, together with some details, of the *Connecticut's* installation are shown in the preceding table.

Motor Action in General.

The table shows that three kinds of motors, as classified by their windings, are employed on the constant potential circuits used on board ship, the series-wound, the shunt-wound, and compound-wound; this selection of motor by type of winding results from the special aptitude of the class for a given duty, in accordance with various well-known principles applying to the motor.

The direct-current motor and the direct-current generator are convertible and have the same general methods of field winding, series, shunt, and compound; there may be a difference, however, as to output when the generator is used as a motor; for instance, a generator developing 100 k. w. at its terminals and having an efficiency of 90 per cent would receive at its shaft coupling about 111 k. w. for its engine; if now 100 k. w. are impressed at the generator terminals to actuate it as a motor to drive a load at its shaft coupling, the generator as a motor would develop only about 89 k. w. in drive, because the 11 k. w. furnished by the engine to overcome the generator losses is now taxed against the 100 k. w. input, and the output of the machine as a motor is lessened by about 11 k. w.; a motor may, therefore, be larger for the same output than a generator.

In a direct-current generator the circuits of the armature are made to cut lines of force by the mechanical power of rotation, inducing a voltage in the circuits if the field is energized. In a direct-current motor the closed loops of the armature circuits tend to place themselves in such a position that their area will embrace a maximum of the lines of force; there being a number of such loops in the armature the effort produces a continuous rotation of the armature, and the rotation enables the shaft to transmit power to a pulley at its end, or rotate a mechanical device which

is direct-coupled. The conditions of the generator are, therefore, opposite to those of the motor; the former receives mechanical power at its shaft to cause the closed loops to alter their position in the magnetic field—cut the lines of force—thereby giving out electrical power at the generator terminals; the latter receives electrical power at its terminals to cause the closed loops (carrying current) to alter their position in the magnetic field, giving out mechanical power to the armature shaft.

It is the electro-dynamic force which causes the rotation of the motor armature; the power which the motor exerts will depend upon (a) *the speed at which the armature revolves,* and (b) *the pull exerted at the circumference of the pulley,* and (b) will depend upon (c) *the radius of the pulley;* the power exerted at the circumference of the pulley is technically known as *the useful torque* (from the Latin *to twist*). The speed at which the armature revolves is governed by the consideration that its armature, revolving in a magnetic field, will also generate a voltage, since the circuits are cutting lines of force, and this voltage, called counter electromotive force (C. E. M. F.) will be opposite in direction to the entering voltage from the supply line; the effort of the motor will be to attain that speed which will cause the counter electromotive force to be equal in value to that from the supply line at the motor terminals; owing to the drop in the armature circuit—the voltage expended in maintaining the current through the armature to overcome the friction, a load in effect—the value of the C. E. M. F. can never equal the applied E. M. F., provided the field is strong. The applied E. M. F. is equal to the sum of the C. E. M. F. and the drop in the armature; but were it possible for this drop to be zero and the C. E. M. F. to be raised to the value of the applied E. M. F., no current would circulate in the armature, no useful torque would be developed, and the motor would revolve only at that speed which is necessary to maintain the C. E. M. F. The radius of the pulley is not generally considered in speaking of useful torque—or rather, it is considered for a radius of one foot—but it will be evident that if a motor has a useful torque about the axis of its armature shaft equal to the pull of a 40-pound weight over a pulley one foot in radius, that is, 40-pounds-feet, it could lift but 10 pounds if the radius were increased to 4 feet; if a pulley of large diameter is

used the force at the circumference will be small; if of small diameter, the force will be large. The case is similar for the work done in a given number of revolutions; a large pulley will have a long lift per revolution, but the weight raised will be small and *vice versa;* for a given weight, and a given torque, the size of the pulley is, therefore, limited. The useful torque of a motor represents the effort force of the motor to cause rotation against the resisting inertia of the load and, considered with reference to its pulley arm, its work done is equal in foot-pounds to

$$\frac{\text{armature current (amperes)} \times \text{field flux (Webers)} \times \text{number of armature circuits.}}{85,155,000}$$

The work done by the useful torque is also equal to the product of that torque and the speed; and the value of the work done is always equal to the product of the current and the counter electromotive force.

When a motor is under load, the load resistance slows the speed until the C. E. M. F. is sufficiently reduced to cause that difference of potential between the applied E. M. F. and the C. E. M. F., which will increase the current to a value that will produce the required torque; this requisite difference in potential is conveniently called the effective electromotive force and is the E. M. F. which produces the given current through the resistance of the armature circuit; knowing the armature resistance and the current, the effective E. M. F. for any instance will be equal to their product; the C. E. M. F. will be the remainder after subtracting the effective E. M. F. from the applied E. M. F., and the power at the instant is the product of the current and C. E. M. F.

The permissible variation of the value of the effective E. M. F. is limited by the current effects of excessive sparking at the brushes and excessive heating of the armature as in dynamos; its variation in value will be equal to from 10 per cent (for a small shunt motor at full load) to 2 per cent (for a large shunt motor at full load) of the applied E. M. F., and these motors will regulate their drop in speed within 10 per cent to 2 per cent of the normal (no load) speed, depending upon the size.

In the foregoing the conditions are based on full field, the ideal being produced by separately exciting the field; but in practice the field is excited by a voltage at the field connections derived from connections to the line supplying the motor, and

this practical method of field supply gives rise to the types of motors known as shunt-wound, series-wound, and compound-wound.

An important consideration in connection with the action of motors is that of varying the strength of the field. Assume the field strength to be reduced one-half, the armature would assume practically doubled speed to produce the C. E. M. F. and for other reductions the speed would vary in proportion; should the field strength become practically nil the flux in the armature due to the current could annul the field flux, the speed would increase indefinitely, the C. E. M. F. would cease, the useful torque would be destroyed, and the motor would tend to stop; short of this, the peripheral velocity of the armature would cause it to fly to pieces. From similar considerations, the armature speed will be decreased by increasing the field strength, because the C. E. M. F. will be produced under this condition at a decreased speed.

It is the reaction of the magnetic field of the motor armature conductors upon the field surrounding them which causes the armature to rotate about its axis.

It is the effect of the tendency to make the reaction equal to the action that causes the speed of rotation to tend to assume that value which would produce a C. E. M. F. equal to the applied E. M. F., the speed assumed being equal to that which would be required in a dynamo to produce an E. M. F. equal to the C. E. M. F. for equal field strength.

It is the mechanical friction and other losses of the motor armature which prevents the C. E. M. F. from equalling the applied E. M. F., and hence an effective E. M. F. is present under even no load conditions.

It is the effective E. M. F. which causes the current through the armature resistance at even no load conditions and which develops useful torque.

It is the increase of the effective E. M. F. which increases the current to produce increased torque for increased load, the maximum current being limited in value by heating and sparking effects. Under constant field increased effective E. M. F. is the concomitant of corresponding decrease of speed.

The Shunt-wound Motor.

In this type of motor the excitation of the field is accomplished (Fig. 135) by a winding which is shunted from the supply line at the motor terminals or their connections; hence, the field

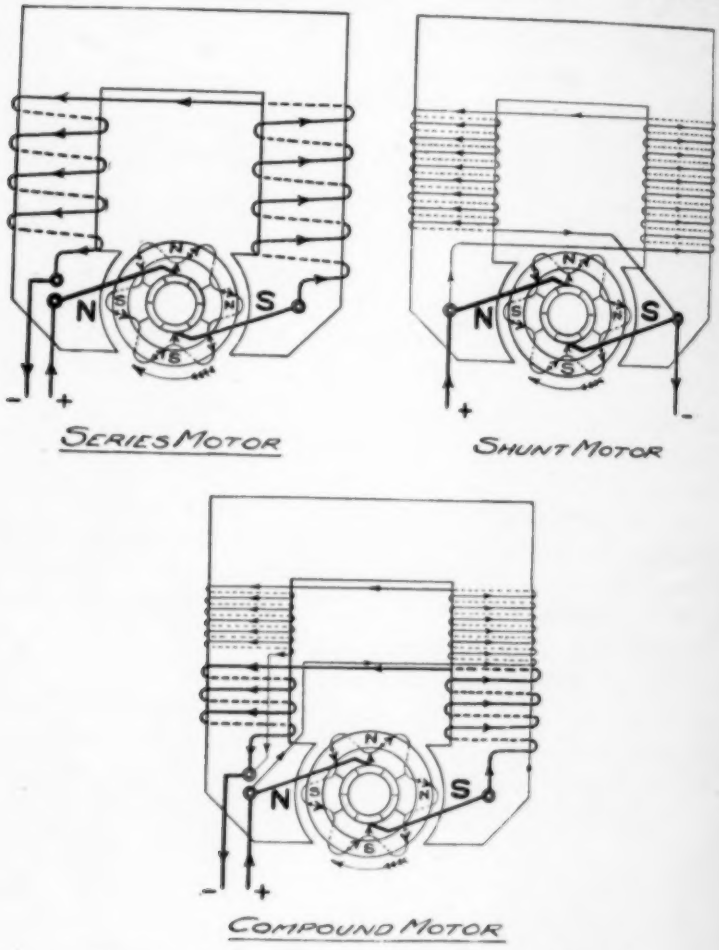


FIG. 135.—Diagram of direct-current motor windings.

is always of the same strength (the voltage of the supply remaining constant), and this condition of constant strength of field is practically that above-mentioned for the full field of separate excitation.

This type of motor will develop but comparatively small differences of speed, owing to the strong field, in generating the variations of C. E. M. F. necessary between no load and full load, and the speed will vary between these limits of load only about 2 per cent for a large motor and 10 per cent for a small motor. This good automatic regulation of the speed makes such speed practically constant and gives rise to the statement that *a shunt motor gives constant speed under variable load* (within its operating limits of load) and that *a shunt motor is self-governing*. The effect of increasing the load is to slow the motor a few per cent until the effective E. M. F. produces the necessary current; sudden variations of increase of load, and overload, produce a rush of current in the armature, which devices in the supply line can be made to control to below the permissible maximum.

Since the field is at full strength there can be no important accession to the field strength on starting, hence the useful torque will not be increased at starting over the full-load conditions as compared with a series motor.

The Series Motor.

In this type of motor the excitation of the field is accomplished (Fig. 135) by a winding which is in series with the armature winding and the excitation of the field is wholly due to the current circulating in the armature at the instant. Under no-load conditions this current will be small and the field be very weak; hence the armature must assume high speed to produce the C. E. M. F. This is the practical case explained for a motor operating under weak field, and so likely is a series motor under light-load conditions to assume that peripheral speed which could destroy the armature that it is mandatory that *a series motor shall always be sufficiently loaded to control the speed within safe limits;* a caution in this direction is that a series motor could destroy itself by excessive speed if all load was suddenly removed from it. The series motor having a variable strength of field, increasing and diminishing in proportion to the current, has necessarily a wide variation in speed between its full load and (practical) no-load conditions, and does not approach self-governing requirements.

At starting and when the current is small in proportion to the diacritical current (that current which will bring the magnet cores up to semi-saturation), the torque is proportional to the

square of the current, and the useful torque is large in comparison with that at full load; this heavy torque at starting is the chief advantage of the series motor.

The wide variations in speed of a series motor usually result in producing an excess of torque for the given load, and this develops an acceleration of speed; this property, together with the great starting torque, is the basis of the commercial use of a series motor for hoists, elevators, and railways; the load starts more promptly, and once started the speed of travel is accelerated.

The Compound Motor (Fig. 135).—This type of winding is a combination of a series and shunt field winding on the same field core and may be *cumulative* (sometimes styled *additive*) when the effect of the series winding is to assist the shunt winding as in a dynamo; or *differential*, when the effect of the series winding is to oppose that of the shunt winding.

The *cumulative* method has the advantage over the simple shunt winding of supplying to the motor that excess starting torque which is lacking in a shunt-wound motor, but the governing, once started, will be inferior to that of a shunt motor but better than for a series motor, and will depend upon the relative strength of the series and shunt field.

A second advantage is that on sudden removal of the load the shunt field will still produce strong field and the motor will not race away. A third advantage is that the series field, by accession of current in its winding, will assist the shunt field in producing torque to overcome increased load, though usually at reduced speed.

The *differential* method produces closer self-governing of the motor than the plain shunt winding; for, as the load is increased, the current circulating through the series winding is increased, weakening the total motor field, and the armature tends to speed up under the weakened field conditions. By proportioning the series and shunt windings, it is, therefore, possible to correct the tendency of a shunt motor to slow down when under load or to increase in speed when unloaded, even within its small natural operating limits, and thus more closely govern the speed. The method is not employed for compound motors on board ship; its close self-governing properties are sometimes availed of for commercial uses where such properties are the major issue.

The availability of the properties of the various types of windings for shipboard use, on constant potential mains, are contrasted as follows:

The series motor is valuable for its great starting torque and speed of action, properties that are well suited to the operation of winches and rammers and for work of this kind the series motor is in general use. An objection to this type of motor for winch practice is the fact that the speed rises dangerously high if the load is thrown off (the fall parting, for example), the strength of the field being diminished by the rise of the C. E. M. F., and consequent drop of current. The motor makes the attempt to attain the speed at which the C. E. M. F. equals the applied E. M. F., each increase of speed diminishing the field current and in turn the C. E. M. F., and calling for higher speed to attain to the applied E. M. F.; theoretically, the speed of the series motor under such circumstances is infinite, but the practical limit is found in the fact that friction and internal losses always make something of a load, so that no motor ever runs absolutely light; in the end, the limiting qualification is the ability of the armature to remain intact under the high peripheral velocity, and the chances are assumed in commercial crane practice from a comparison in cost, the series type of motor being comparatively cheap.

The shunt motor preserves a practically constant speed; it has, however, the great defect of having small starting torque as compared with a series motor under similar conditions. The special adaptation of the shunt motor is to start with no load or with a light load and afterwards preserve a practically constant speed; the apparent exception of the load imposed by turret turning, gun elevating, and whip hoists, has, therefore, to be met by large power in comparison with the actual required for the duty. The great advantage of the shunt motor is, then, its good self-governing features, the property of constant speed, and this property is preferable for the vast majority of motors installed in the list on pages 334 to 337. It will be noted that of motors of one horsepower and above the most are shunt motors, and for a majority of the *classes of duty* the shunt motor is also preferred and best.

The compound motor, with cumulative winding, is very generally installed for the operation of electrically operated water-tight

doors and power hatches; it is installed for the operation of winches on board of the *Connecticut*.

Its advantage for use with water-tight doors is due to the good starting torque and that when the door meets an obstruction in its path—such as the wedges in case of the usual door, or wedges and coal over the threshold, in case of a bunker door—the new resistance slows the armature; the effective E. M. F., and consequently current, is increased; the series field is increased, strengthening the total field; more current results and the action becomes cumulative. And, although the armature is slowed, the large increase of field and current increases the torque; the net result is that the motor exerts a strongly increased power in closing the door, but at reduced speed, the latter not being an important disadvantage for the particular duty.

For the case of the power hatch the compound motor has advantages of good starting torque combined with fairly steady speed after starting.

Its advantages for winches resides largely in the protection afforded the motor against racing in case of loss of load, an important feature in ship duty.

Motor Reversal and Control.

Motor Reversal.—If two generators, one series-wound and the other shunt-wound, have been connected up as generators and both are to revolve clock-wise, for example, and current is supplied separately to each at constant potential to drive them as motors, the current entering at the positive, generator, terminal in each case, it will be found that the *shunt-wound machine* continues to revolve clock-wise as a motor, and the *series-wound* machine revolves counter clock-wise; the former has assumed the same direction of rotation as when driven as a generator while the series-wound machine rotates in the opposite direction to that in which it was driven as a generator. This arises from the fact that in the *shunt-wound* machine the current in the field is in the same direction as when operating as a generator and the directions of the lines of force are the same; and hence, to oppose the applied voltage, the armature must revolve in the same sense as when operating in the generator; the case is different for the *series-wound* machine because the applied voltage reverses the

field, and hence the motor must build up a C. E. M. F. by a counter-clock-wise rotation.

If now we reverse the direction of the applied E. M. F. by connecting its positive side to the negative generator terminal, the shunt-wound motor will still rotate clock-wise, and the series-wound, counter clock-wise; reversing the polarity of the applied E. M. F. has, therefore, effected no change in direction of rotation in either case and for the reason that the reversing process used is applied as well to both field and armature; reversal of direction of rotation of the motor is, therefore, to be accomplished by reversing either the field current, or the armature current (the ordinary method), *but not both.* In a shunt motor the object is readily accomplished by constant excitation of the field and reversing the motor by reversing the current entering the armature; in most shunt motors installed on board ship for which reversal is desirable the fields are already separately excited for speed control; a reversing switch in the armature leads makes reversal a simple problem.

The design for a reversing switch for a series motor breaks both the armature and field current at the same instant, that is, both field and armature have no applied E. M. F. at the "off" position of the controller, and hence the proper conditions obtain for connection to the line; this is different from the condition for a shunt motor whose field is kept excited directly from the mains whatever the position of the reversing switch, whether "off" or "on" in either direction.

Motor Control.—This term is applied to the operation of circuit devices by which the motor can be operated at varying speeds; it commonly embraces also that type of apparatus for starting motors which are intended to operate at rated speed and which are known as starting rheostats or starting boxes, which, though not intended in any sense to vary the speed, are still a part of any speed control design, as regards their simple features at least. The systems of control used in the Navy are starting rheostats, the Leonard system, the Day system, and the Panel (or Multi-voltage) system.

Starting Rheostats.—It is evident that a motor must have time to start and develop C. E. M. F. before the total E. M. F. of the supply line can be applied; otherwise, an enormous current

would result which would seriously injure the brushes and commutator and could destroy the insulating materials in the armature, or, in common parlance, would probably burn out the motor; and the object of the starting rheostat is to provide a means of supplying the total applied voltage gradually, though in a fairly brief time, and thus afford the requisite time to overcome the inertia of the armature and establish the magnetic reactions; the simplest method is to insert a variable resistance in the supply line.

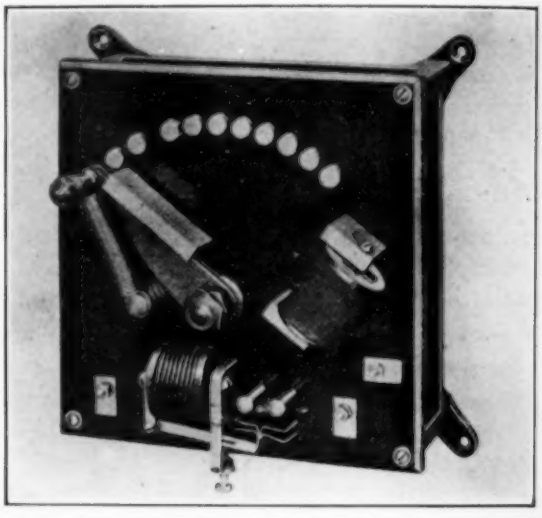


FIG. 136.—Motor-starting rheostat with no-voltage and overload release.

A type of starting rheostat for a shunt motor which is complete in all essentials is shown in Fig. 136. The design consists of a non-combustible box in which the resistances are enclosed. The cover, to which the various electrical connections are secured, is made of some non-conducting material, more often slate or marble. Near the top of the cover are brass studs or blocks which pass through the cover and are connected the one to the other through the resistances; these resistances are not necessarily distributed equally between the blocks but may differ or have a series-parallel connection according to convenience of design, and the resistances may be of any form, coil, metal sunk in enamel, ribbon in asbestos, etc., as may be best for compactness.

The diagrammatic connections are shown in Fig. 137, from which it will be seen that the spring lever can be gradually passed, a few seconds per block from the left-hand blocks on to the right, passing from block to block and cutting out resistance until it finally reaches the extreme right-hand block, when all resistance due to the rheostat is cut out and the motor armature is receiving the full voltage of the supply line, the losses of voltage before arriving at the last block having been dissipated in heat in the

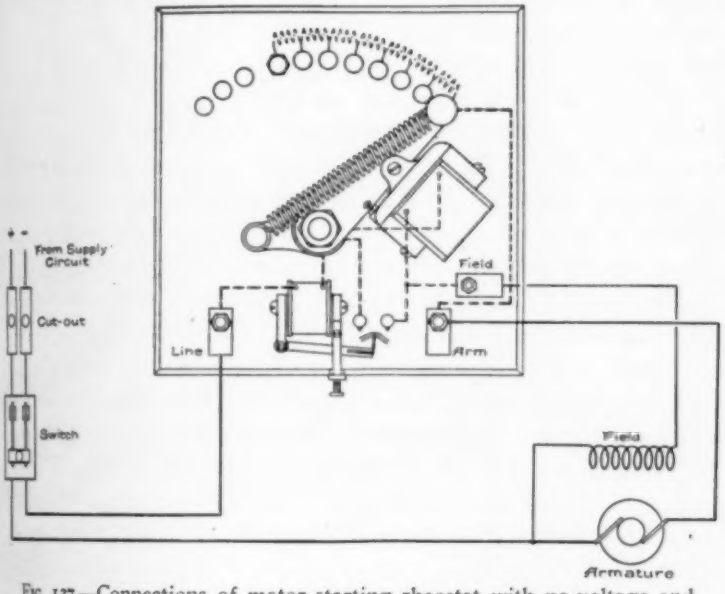


FIG. 137.—Connections of motor-starting rheostat with no-voltage and overload release.

rheostat. The three left-hand blocks shown are merely mechanical adjuncts as a rest for the spring lever, and at which the circuit is open, or "off."

It will be noted that *the motor field is energized before any voltage is applied to the armature,* as will appear from the connections; this is mandatory in starting shunt motors, which would on account of weak field start under irregular conditions of excess of current, sparking and heating, were the field connections shunted directly from the armature terminals as in a short-shunt dynamo; it is essential that a comparative period of time elapse in getting the field to full strength.

The device shown on the right side of the cover is an electromagnet connected in the field circuit and is called *the no-voltage-release magnet;* it holds the spring lever to the right-hand block by the attraction of its pole pieces on a soft-iron armature attached to the spring lever as long as any current is passing from the supply line; if the voltage fails from the opening of a circuit breaker or blowing of a fuse the spring throws the lever back to the left-hand blocks since the no-voltage-release magnet can no longer attract the armature and hold the lever. This safeguards the motor against the contingency of leaving the spring lever on the right-hand block when, the voltage of the line having been re-established by closing the circuit breaker or by a new fuse, the total electromotive force of the line would reach the armature when at rest, or when not developing sufficient C. E. M. F.; this is the very thing that the starting rheostat is intended to prevent. The no-voltage-release magnet is, therefore, to be regarded as a *sine qua non* for proper design in any starting rheostat.

The device at the bottom of the cover is connected in the armature circuit and is known as the *overload-release magnet.* It has a pivoted armature at whose outer end are two contacts, electrically connected, which, when the magnet armature is attracted, short-circuit two binding posts, shown; these binding posts are the connections of the no-voltage-release magnet, and these, being short-circuited, deprive the magnet of current; hence, the magnet releases the spring lever and the spring brings the lever to the left-hand block as in the ordinary case of the operation of this magnet for no-voltage release. The device protects the armature from any current whose value is greater than that permissible, and its magnet is so adjusted as not to operate below that current. An intent of the overload-release magnet is, however, to guard against the overload on a motor which is so often occasioned by the carelessness of that attendant who, in starting the motor, moves the lever too rapidly over the blocks; the inability of the motor to establish its speed and the necessary C. E. M. F. would result in such a case in a large excess current; this particular intent in this device is said to have given rise to a characterization for this and other designs on similar lines, particularly in alternate-current work, as a "fool-proof" device. Notwithstanding the protection afforded by the overload-release de-

vice, it is frequently omitted in designs of starting rheostats and a fuse in each pole substituted.

It is important to remember that the starting rheostat is not to be used as a controller to vary the motor speed. Although the variable resistance can effect a control of speed the resistances are designed to endure the current only for that short time which is necessary to start the motor, hence any attempt to regulate the motor speed by leaving the lever on other than the armature stop would result in unduly heating the resistances and they would finally burn out; and only because they were not designed for a protracted heating effect of the current used in starting.

The Leonard System of Control.

This system was designed by Mr. H. Ward Leonard, to reduce to the lowest practicable limits the amount of energy required in starting and operating motors. To start a motor properly it is necessary to apply at first only a small proportion of the maximum voltage of the circuit from which it is actuated, and gradually increase to the full voltage of the line. In the customary methods, this is accomplished by a rheostat whose resistance, combined with that of the motor armature, is sufficient to keep the current to about 1 or 1½ times the rated full-load current at the time of first closing the circuit; the result is that half or more of the fall of potential takes place in the rheostat and becomes lost energy; but *if the voltage is generated only in the amount actually required for the time being,* this rheostat loss can be obviated, to the economy of energy.

The system is employed for the shunt motors for turret turning, and in recent practice for gun elevating, and combined with it is the advantageous expedient for refined control of speed, separate excitation of the motor fields independently of the armature circuit, and a further combination for reversal is afforded by the separate excitation in that the excitation being constant in direction, reversal is easily accomplished by merely reversing the entering direction of the armature current. All these processes—varying the generator field to control the voltage, separate excitation of the motor fields, and the reversing switch—are included in the design of the controller device and operated in a simple motion of the controller lever.

As applied to turret turning and gun elevating, Mr. Leonard's method is shown in an elementary way in Fig. 138. *L* and L^1 are the line wires of the supply circuit from the switchboard. *GF* and *MF* are the generator and motor field circuits that are excited by the supply circuit. The voltage of the generator field can be controlled in amount as required by the variable rheostat, *R*. The motor field, *MF*, is separately excited from any lines leading from the switchboard other than those connected up with the generator, *GA* (or that employed for operating the turret-turning motors); the motor fields are, therefore, constantly excited to the full voltage of the line feeding them. *GA* and *MA* are the armatures of the generator and motor, respectively; *RS* is a reversing switch through which the direction of the current flowing into the terminals of *MA* can be changed.

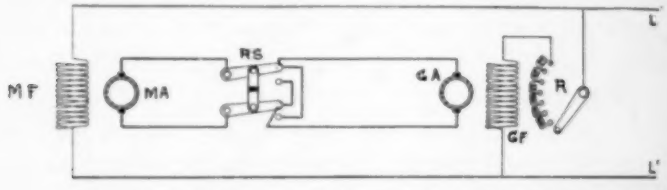


FIG. 138.—Diagram of Leonard system of control.

The operation is as follows: The generator is driven at the constant speed required for its *full output* by some prime mover such as a direct-connected engine (or motor, in motor generators). When the rheostat in circuit with the generator field is open, no voltage is generated in the generator armature; on closing the rheostat circuit, the current flowing will magnetize the generator field and the generator armature will generate a voltage, and, when the reversing switch is closed, this voltage will be that at the brushes of the motor armature also. As soon as the voltage has risen to a sufficient value, the current, which has been increasing as gradually as the voltage, will finally produce just the requisite torque to turn the motor armature. As the motor field is constant and at full strength, the necessary torque will be produced with a minimum of current.

It will be seen that there are no losses in motor armature rheostats, and that no sudden shock has been applied to either the generator or motor. The speed of the motor may be increased

gradually to the maximum, which will obtain when all the resistance due to R is cut out of the generator field as the generator will then give its maximum voltage.

The direction of rotation of the motor is changed by the use of the reversing switch which reverses the polarity of the motor armature terminals, the current entering oppositely. A strong braking action can be obtained by short-circuiting the motor armature at the time when the load tends to rotate that armature after the generator voltage has been cut off, as the motor will then be acting as a generator, through a low resistance, and the drag on its armature will tend to stop it.

The method of practical application of the system is explained in connection with the connections for turret-turning motors.

The Day System of Control.

The system was invented by Mr. Maxwell W. Day of the General Electric Company.

The controller is similar to the well-known street car style of construction, but has a system of connections especially adapted for hoisting work (for which the control of the speed in lowering is a very important matter on account of the high efficiency of the hoisting mechanism) the system permitting the load to overhaul for hoists in which the ordinary crane practice of using a series motor and solenoid brake would be unsatisfactory. The connections are so arranged that in hoisting the load a portion of the rheostat is introduced into the armature circuit, but not quite sufficient to start the full load on the first hoisting notch, or position, of the controller. The second notch cuts out sufficient resistance to cause the load to start, and the other points on the controller will give a control of speed. This system of connections is shown in the elementary diagram (Fig. 139), which represents the successive steps, 5, 4, 3, 2, 1, of cutting out resistance, until full speed is reached. As the resistance is turned out of the circuit, the speed increases, and as the resistance is turned into the circuit, the speed diminishes, until on the "off" position, the main circuit is broken, and the armature is short-circuited on itself, producing a powerful brake effect, causing the armature to instantly stop and prevent any rapid descent of the load, although the load will descend slowly unless some other mechani-

cal device is provided to prevent it. A contact is provided on the controller to energize the solenoid brake magnet, so that the solenoid armature is lifted up and the brake released whenever the controller is turned away from the "off" position; as soon as the controller is turned off the magnet loses its strength and the brake is immediately set.

As the load would not always be sufficient to start the motor easily from a state of rest, it is necessary to provide some means of causing the motor to operate as a motor in case the load will not start it as a generator. For this purpose the connections are made as shown in the diagram, "lowering" (Fig. 139), the rheostat being connected across the line; and on that account the rheostat is made of considerable more resistance than is required for starting the motor in hoisting in order to prevent

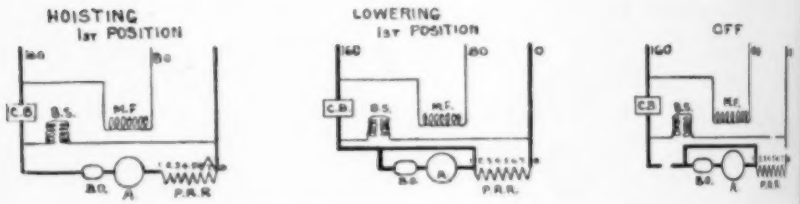


FIG. 139.—Diagram of Day system of control.

useless waste of current through the rheostat; the resistance is such that this current may amount to 15 or 20 per cent of the full-load current of the motor. In the first lowering position of the controller for this arrangement, the armature is short-circuited on itself and both lines are connected to the rheostat. The next position puts the armature in multiple with a portion of the rheostat; the armature will now receive current from the line, in case it does not start of itself or it will produce a current through this portion of the rheostat in addition to the current passing through it to the line. In the next position, more resistance is put in multiple with the armature, and the greater current is taken from the line, if the motor does not start, or a higher speed as a generator is produced if the motor acts as a generator. In this system this portion of the rheostat may be considered as being in multiple with the armature as regards the

current received from the line, and in series with the armature as regards the current produced by the armature itself.

The feature of the Day control is the electrical braking action of the motor armature when, as actuated by the load, it is operating as a dynamo.

The electrically operated mechanical brake, or solenoid brake, often used as an adjunct to this system of control is shown in diagrams *A* and *D* of Fig. 140.

1 and 2 are the two solenoid coils attached to, and embracing the cores of, the yoke 14. A weight, 3, with cores, 4, 5, is attached to the brake lever, 6. As long as the coils 1 and 2 are

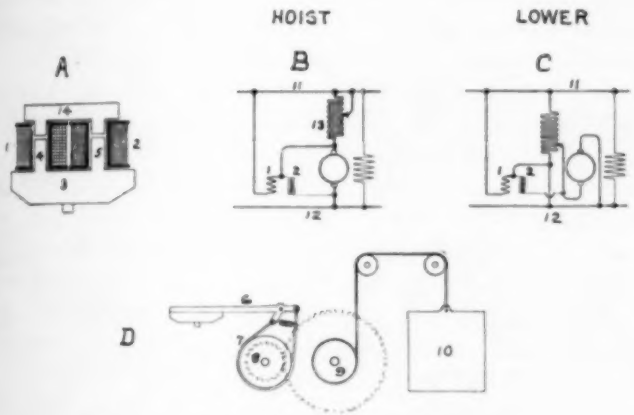


FIG. 140.—Day system differentially-wound.

not energized the weight, 3 (and brake lever, 6) will be free to fall, and from the arrangement of the pivot of the brake lever as shown, and the brake band, 7, the weight of the brake lever will *set up the brake band* against the brake wheel, 8, attached to the motor armature shaft; if the coils 1 and 2 *are energized* the cores 4 and 5 will be attracted and the brake lever will *release* the brake band from the brake wheel. 9 represents the drum or gypsy around which is taken the fall or rope for hoisting or lowering the weight, 10.

The application just described contemplates that the brake solenoid coils shall be similarly wound and both coils shall be connected in series across the mains. In the more recent patent, solenoids 1 and 2 (Fig. 140) are not wound alike but have a

difference in their number of turns and size of wire as shown. The connections are made, as shown in diagrams *B* and *C*, to a contact at the solenoids to which one end of each coil, 1 and 2, is led; 1 is then connected back to the positive main, 11, while 2 is connected to the motor armature circuit. In hoisting, diagram *B*, solenoid 1 shunts the resistance, 13, while solenoid 2 shunts the armature. Before the motor starts in lifting, substantially the whole electromotive force of the line will be consumed by the resistance, 13; coil 1 will be strongly energized, while coil 2 will receive practically no magnetization, being short-circuited by the armature; but, as the motor begins to attain speed, its increase of counter electromotive force will shunt an increasing amount of current through coil 2. When the motor has reached full speed, nearly the whole electromotive force of the mains is consumed in the motor armature; coil 1 now ceases to perform its function of holding the brake released, but coil 2, receiving the full potential of the mains, is sufficient to prevent the lever arm from dropping and setting the mechanical brake. This office coil 2 is able to perform the more easily since the cores, 4, 5, have already been drawn close to the yoke, 14, and the magnetic reluctance between the cores and the yoke, 14, is, therefore, small. The device requires only that loss of energy which is due to coil 2 and which is substantially less than for two similar coils connected in series.

In lowering, diagram *C*, the connections of the brake solenoid are altered. Current can still flow through coil 1 as before, but it passes by the connection, shown below the resistance, out of the negative main. Since the armature current is reversed the direction of the current through the circuit of coil 2 is also reversed, as it shunts the armature, and would tend to demagnetize the coils, 4, 5, by neutralizing the action of coil 1, and, at the full-speed position, would practically accomplish it and cause the brake to be applied were coils 1 and 2 of the same resistance; but as the construction of coil 2 is of finer wire its magnetizing power is small and the cores retain enough magnetism to hold the brake released. When the motor acts as a dynamo, coil 2 holds the friction brake released, but sets it when the motor slows down and the current which the motor is generating lessens.

The practical method of application of the system is explained

in connection with the connections for the 13-inch turret ammunition hoist.

The Panel (or Multi-voltage) System of Control.

This system is a method of changing from a higher to a lower voltage and *vice versa* for some motors on the *Kearsarge* and

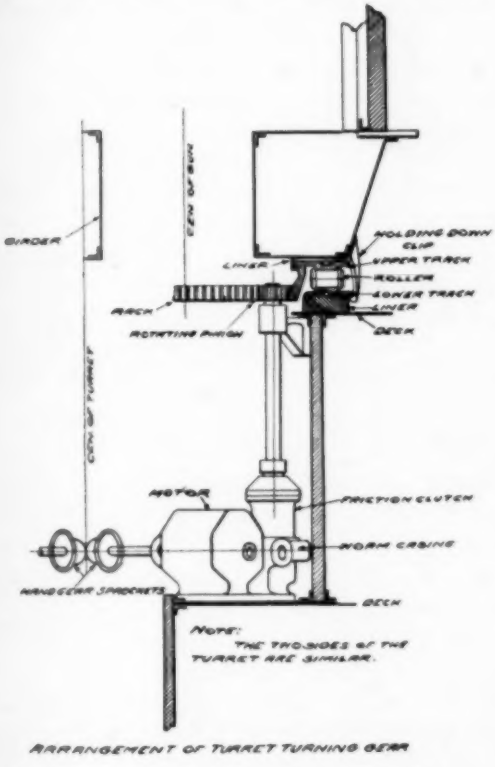


FIG. 141.—Turret-turning system. Elevation.

Kentucky which can be energized by multiple voltage; it is explained in connection with the particular motors and class of duty.

Turret-Turning Motors.

One of the latest arrangements for the turret-turning system is shown in the sketches of Fig. 141 (elevation), and Fig. 142 (plan).

Two motors, independent of each other, have their shafts con-

nected together by beveled gears. Each motor has a bevel pinion on its shaft which meshes with a similar bevel pinion on a worm shaft; the worm drives a horizontal worm wheel which is connected to a vertical shaft through a friction clutch; and the vertical shaft, through a pinion at its upper end which meshes with the rack at the base of the turret, drives the turret. The friction clutch is set tight enough to drive the turret under usual operating conditions, and is of the cone type. Should the clutch be overloaded it will slip and protect the gears.

The beveled gear wheels are fitted with sprockets for attaching hand gear by chain in case the motors are disabled.

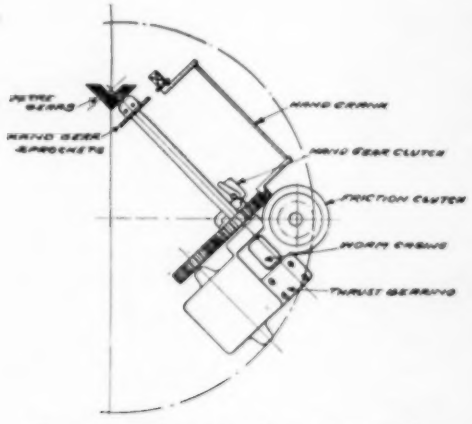


FIG. 142.—Turret-turning system. Plan.

[NOTE 23.—In an older system installed the motors are secured to brackets on the walls of the handling room and at the proper height for engaging the gears. Both motors revolve in the same direction, both driving through bevel gears to one shaft which runs across the turret; the object of the cross-shaft is that one motor may drive the turret by driving both pinions should the second motor be electrically or mechanically disabled, and also to permit one motor to revolve the armature of the other motor through the bevel gears, instead of through the worm wheel and worm, should the other motor fail electrically. This shaft carries at one end a right hand and at the other a left hand worm, each of which engages a worm wheel at the top of a vertical shaft. At the lower end of each vertical shaft is a pinion which meshes with the circular rack inside of the barbette and thus drives the turret. The worm wheels are connected to the vertical shafts by cone friction clutches which can be adjusted by nuts to carry the desired load, or to slip off, if the load be exceeded, to prevent damage to the driving mechanism from an excessive overload.

such as occurs when firing one gun or from the impact of a projectile on the outside of the turret tending to produce a rotation of the turret independently of the motors.]

The Motor.

A type of motor used for turning 8-inch turrets superimposed on 13-inch turrets, unbalanced, is shown in Fig. 146. It is rated at 50 horsepower, and is of the enclosed, armored type, 4-pole, and classified by the General Electric Company as C. B.-11-B.-1. It is shunt-wound and is designed for an armature speed of 400 r. p. m., and an input of 540 amperes at 80 volts, full load.

The magnet frame is an octagonal steel casting made in two pieces. Feet are cast on the lower frames and are drilled for bolting the motor to its foundation. The upper frame is held in position by six steel tap bolts.

The pole pieces are of cast steel and are bolted to seats bored in the magnet frame and located at 45 degrees from the horizontal. In assembling they must exactly fit their seats or the air gap will be altered and the pole tips be likely to strike the armature, as there is no dowel pin or key.

The armature bearings are cast on the lower frame and are fitted with removable caps and split linings. They have large pockets for catching the waste grease. The caps are held in position by steel bolts and have large grease boxes cast on which are fitted with composition covers, held in place by copper-plated steel springs. The armature-bearing linings are cast iron, babbitted, and made in two halves; they are provided with slots for admitting the grease lubricant to the shaft.

The armature is the usual slotted-core, barreled-wound type.

The brush rigging consists of a revolving cast-iron yoke, made in two pieces, fitting on the commutator end bearing. The yoke supports four insulated brass studs which are cross-connected by 288,000 cm. cable, rubber-insulated, and braided to 1.1 inches outside diameter. Each stud has six brush holders with carbon brushes, 1 by 1¼ by 2½ inches, similar to those used on the form G dynamo. The brush-holder springs are adjustable to give proper tension to the brushes. The brush-holder cables are brought out through the front end of the lower frame by two brass connection bolts which are insulated from the frame by fiber washers and bushings.

There are three large rectangular **hand holes** in the upper frame immediately over the commutator through which the brushes can be sand-papered and fitted; they are provided with cast-iron covers, made water-tight by soft rubber gaskets, and held in position by bronze wedge bolts. The ends of the upper frame have semi-circular openings fitted with malleable-iron covers which are held in place by bronze cap screws and made water-tight by soft rubber gaskets. If desired, the semi-circular covers can be left off for ventilation. To allow for examination and adjustment of the lower brushes, two circular hand holes

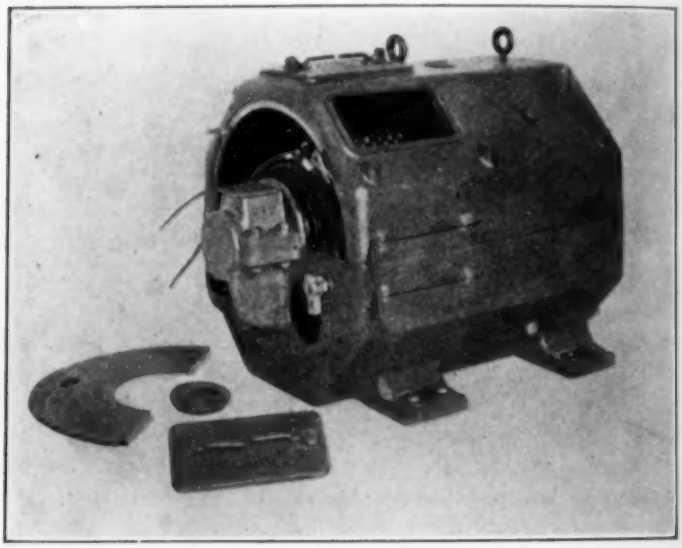


FIG. 143.—Motor for turret turning.

are cast in the commutator end of the lower frame and are fitted with cast-iron covers held in place by springs. To sand-paper the brushes on the lower studs, it is necessary to disconnect the brush-holder cables and revolve the brush-holder yoke until the lower brushes are brought to the top where they can be reached through the rectangular hand holes.

The (two) motors for turning the single 12-inch balanced turrets are of similar construction. They are rated at 35 horse-power, at 80 or 125 volts, and also have a rated speed of 400 r. p. m.

The (two) motors for turning each of the single 8-inch balanced turrets follow the same general design, having an output of 15 horsepower at 125 volts, and a rated speed of 400 r. p. m.

The Controller for the Turret-Turning System and its Operation.

This especial type of controller, known as the "P" type, is used when the voltage of the *generator field and armature* is to

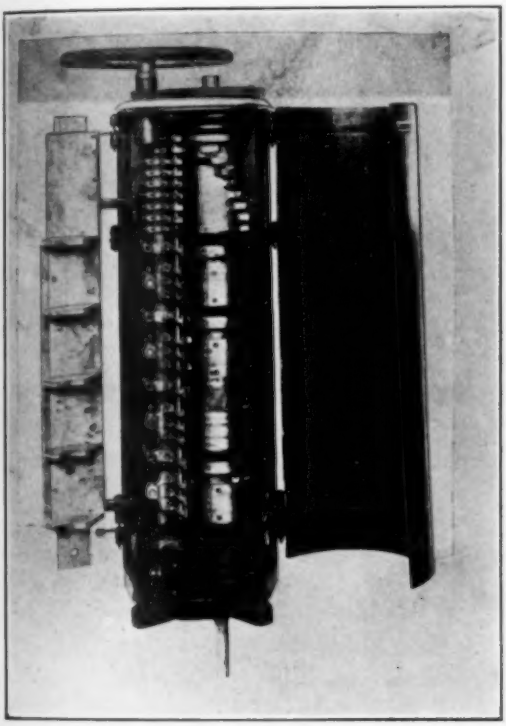


FIG. 144.—Controller for turret turning. P-2 type.

be varied to change the speed of the motor, on the Ward-Leonard system, and is, therefore, called a variable voltage controller. It is radically different from other controllers, both in design and system of control; while it retains the general features of all controllers, the proportion and arrangement of its contacts are quite different.

There are two typical varieties: that used with the superimposed turret system, and known as the P-2 controller; and that used with the single 12-inch balanced turret and known as the P-10; both notations are those of the General Electric Company.

The P-2 Type of Controller.

This typical design is shown in Fig. 144 and is that used in the *Kearsarge* for the turret-turning system.

The frame is a cast-iron plate, having a projecting shelf or ledge at the bottom, provided with four drilled lugs for fastening. The cover is of sheet iron, semi-cylindrical in shape, and held by hinges and swinging bolts. At the bottom is a bearing for the cylinder shaft, the upper bearing being in the cap-plate. To remove the cylinder, take off the cap-plate and pull it straight up, as the shaft extends through the bottom of the controller and the lower bearing has no cap.

The cylinder is supported on a steel shaft 1½ inches in diameter, and consists of a wooden cylinder, pinned to the shaft, supporting cylindrical castings for the contacts. There is one cylindrical casting at the top, with one continuous ring and eight pairs of short segments for controlling the field of the generator. There is so little danger of burning these segments that they are not provided with removable pieces. Below these there are two castings on one side of the cylinder and three on the other, which take the armature connections and are provided with removable segments or contact rings. Of these, four on each side for making the armature connections are 3 inches wide; there are three others for auxiliary rheostat connections with are 1 inch wide. All of these segments are provided with removable tips that may be removed without removing the entire segment.

At the bottom a coupling connects the controller to a vertical shaft which is mechanically operated by stops at nearly the limit of travel of the turret, turning the cylinder to the "off" position. This safety device prevents that degree of rotation which would allow the guns to strike the superstructure. Dependence should not be placed upon it except for emergencies, but it will usually serve to notify the operator when he is approaching the limit of train by automatically moving the handle.

On the wooden blocks supported by the frame are several

contact fingers, insulated by the block from each other and from the frame. The fingers are stamped from copper and are held in position by springs and adjusting screws, so that when the cylinder is rotated its segments will make firm contact with the fingers whose springs give sufficient pressure to ensure good electrical connection. The fingers are supplied with binding posts in which wires or cables are fastened, making the necessary connections between the line switch, motor, and rheostats. The wires are carried directly out through the back of the frame, being insulated from it by rubber bushings. The fingers are fastened in their bases by small screws which permit the replacing of any which may be injured. The adjusting screw is provided with a check nut that the screw may not jar loose after the finger has once been adjusted.

The bases are fastened to the wooden block, and the wooden block to the controller frame, by screws.

There are two kinds of contact fingers used; those at the top are ½-inch wide and have bases which are provided with binding posts for the connections to the generator field and rheostat; the other fingers are 1-inch wide and are arranged in sets of three each on a common finger base for the main contacts, and single fingers for the auxiliary contacts. The finger bases are provided with binding posts for the main leads. On the back of the controller are two sets of three fingers each, mounted and connected to a brake rheostat.

Blow-out Magnet.—In order to reduce that burning of the segments and fingers which is likely to result from the operation of the controller, a magnetic field is provided which has the effect of instantly breaking the electric arc formed when a circuit is broken. This magnetic field is produced by a spool or coil surrounding the lower end of the cylinder shaft. In addition a steel pole piece is supported over the fingers which is connected magnetically at the bottom to the bearing of the shaft, forming a magnetic circuit consisting of the shaft, bottom of the controller frame, and the pole piece, the circuit being completed by the air space between the pole piece and the shaft, and supplying a magnetic field along the end of the fingers. There is some magnetic field on the other side of the controller cylinder, between it and the back of the controller, but only that portion formed between

the pole piece and the shaft is employed in blowing out the arc. The magnet coil is located at the bottom of the frame and surrounds the lower end of the cylinder shaft and its bearing. The magnet spool is provided with two binding posts, one of which is connected to one of the finger bases, and the other to the circuit.

Arc Deflector.—To more thoroughly insulate the fingers from each other and from the cylinder and pole piece, strips of fireproof insulating material are provided, extending between the fingers and pole piece, with division plates extending between the fingers themselves. The division plates are placed between the main contacts only, as the current for the field contacts is so small that more are not necessary.

Star Wheel.—That the operator may judge the position of the cylinder while operating, without looking at it, a wheel is fastened to the cylinder shaft (in the usual controller this contains several notches or teeth); these engage a roller, supported on the end of the pawl, which is pressed against the star-wheel by a spring. As the cylinder is rotated the pawl offers resistance to the movement of the handle, and, as it moves into the notches, the effect is plainly felt by the operator. The controller handle should rest only in the position shown by this pawl and star-wheel, as it is at these points that the fingers make the best contacts with the cylinder; it should not be left at intermediate points. In the particular type used for turret motors the star-wheel is located at the upper end of the shaft and contains *but one notch*, located at the "off" position; others are not necessary as the main circuit is broken at the time of starting and stopping and the current controlled by the upper part of the cylinder is small. The star-wheel gives the additional advantage of making a quick break at the time of passing from one position to another, the tension of the spring helping to turn the cylinder after the roller has passed the point between two notches. It is essential that this controller should operate easily and not interfere with the training of the gun; it should have a plainly marked point at the "off" position.

The cap-plate is a semi-circular brass casting at the top of the controller containing the bearing for the cylinder and a bearing for the secondary shaft which is connected by gearing to the

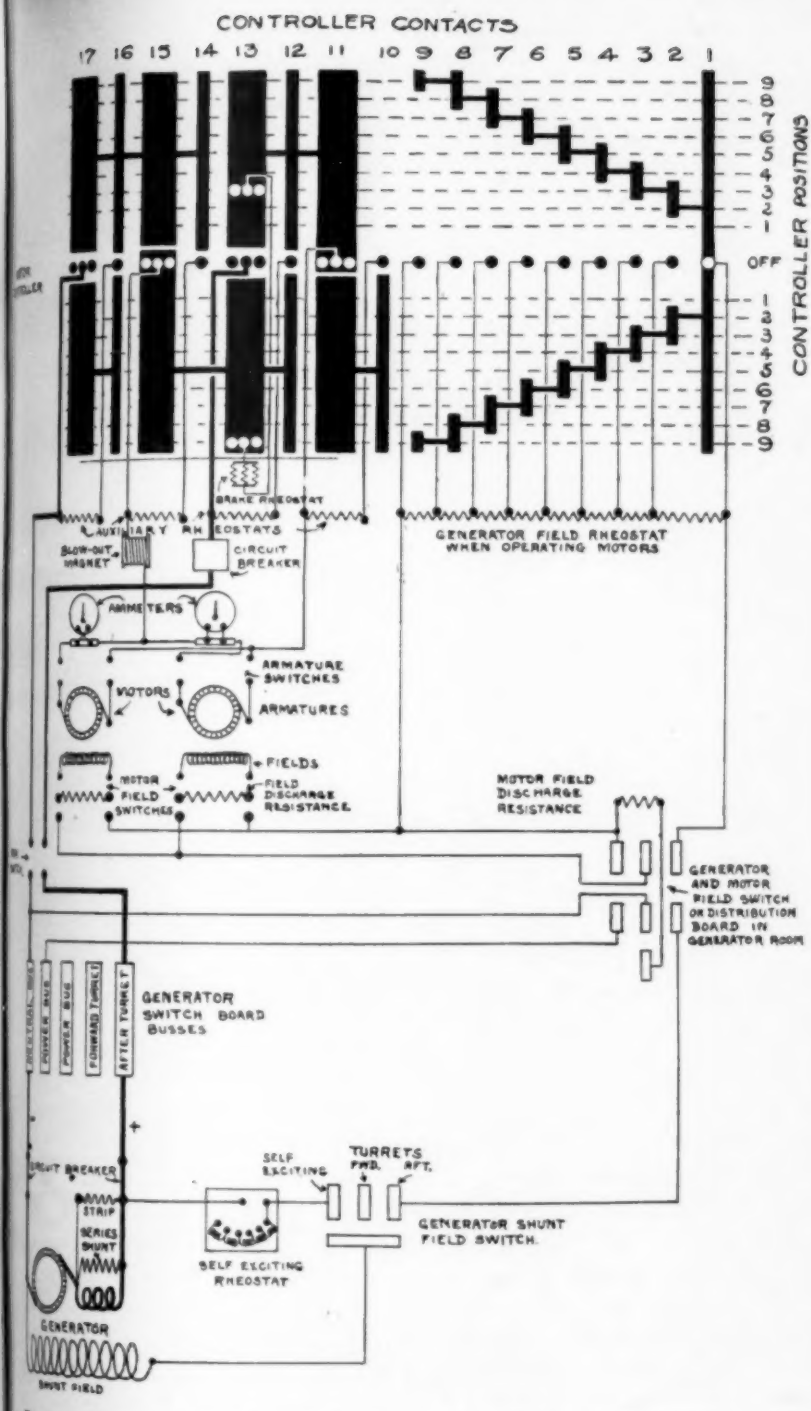


Fig. 145—Diagram of turret motor connections of the *U. S. S. Kearsarge.*

cylinder. It has a pointer to show the position of the gear and indicate the position of the cylinder.

The handle, instead of being carried on the main cylinder shaft, as in other controllers, is carried on the secondary shaft, which is connected by pinion and gear of about 4 to 1 reduction to more easily operate the main cylinder. While the main cylinder turns nearly half a revolution in each direction from the "off" position, the handle itself turns more than three and one-half revolutions. The gear carries marks on its top surface to show the position of the cylinder. If it is desired to operate the cylinder directly the pinion gear may be easily removed and the handle put directly on the main shaft, in which case the index points on the cap-plate will show the position of the cylinder. If desired, a hand-wheel may be used instead of the handle.

The operation of the controller as an adjunct to the Leonard system of control is shown in the diagram of Fig. 145, which represents the connections as applied to the after turret of the *Kearsarge*. The diagram contemplates the operation of two motors in the same turret from a single dynamo room generator, and in tracing it, it should be remembered that most power circuits of the *Kearsarge* are installed for both three-wire and two-wire use, explaining that switch-board bus which is marked "neutral bus"; that the 50 k. w. generator operating the motors has a German silver connecting strip, by which the series field can be partially cut out and the generator run mainly as a shunt machine, a small amount of excitation by the series field being retained in the shunt action of the strip to have its slight effect on the voltage of the generator, thereby causing the turret to start more promptly than would be the case if the shunt winding alone were employed; and also that any one of the seven, 80-volt compound-wound dynamos in the ship can be used either for lighting, or for running either the forward or after turret, or for other power or electrical uses.

The generator armature, shunt field, series field, and series shunt are shown in Fig. 145. The circuit breakers connect the terminals to the neutral and after-turret bus bars on the switch-board; the strip shown just above the series shunt, is located on the same base with the circuit breaker next to it, and is that strip which partly, but not wholly, short-circuits the series field

when the generator is to be used for operating the two turret motors shown.

The "self-exciting" rheostat is the one used with the dynamo when running for all purposes other than turret turning; in such cases the switch is closed across from the connection marked "self-exciting" (the strip at the circuit breaker must then be open).

The controller cylinder performs two distinct offices. The upper part has nine contacts which are connected by fingers and leads to the generator field rheostat. The lower part supports a number of semi-circular segments, of which those marked 11 and 15 connect with the motor armature, and 13 and 17 connect with the switch-board; these segments form the reversing switch between the generator and the motors. Attached by a pair of auxiliary contacts to the two divisions of segment 13 is a brake rheostat, whose circuit to the motor armatures is completed on the "off" position through segments 11 and 15; the rheostat introduces a brake resistance across the motor brush terminals when the controller is off, which checks the momentum of the turret and the motor armatures due to the energy required to drive the motor armatures as dynamos, thus generating current through the brake rheostat. This current decreases with the speed, becoming zero when the turret is at rest; it gives the greatest braking effect at first, diminishes as the turret is retarded and produces a smooth stop.

The initial current in the brake circuit is dependent upon the speed of the turret when the circuit is closed, and it is desirable that the turret speed should be as low as possible in order to reduce the current and prolong the life of the fingers and contacts in the controller. If the turret is turning at full speed and the controller handle be moved very rapidly to the "off" position, a current of 1000 amperes or more may be generated through the brake resistance and cause roughness of the finger contacts.

As the motors will generate current through the dynamo armature circuit, when the controller handle is turned to the position for lower speed than that which the turret is actually running, a braking effect is produced which will not require that any circuits be closed or opened and, therefore, produce no arcs. This is the desirable method of retarding the speed of the turret and

should be used except in cases of emergency, as it is found it is better to bring the turret to a low speed when approaching the target and before throwing the controller to the "off" position than to attempt a sudden stop from high speed. The braking effect of the motors running as generators is indicated by the reversal of the direction in which the ammeter pointers swing.

In addition to the wide segments there are narrow ones, 10, 12, 14, and 16, which make contact at their respective fingers a little before, and break a little after, the segments which they connect. They introduce resistances into the armature circuit known as auxiliary resistances, the object of which is to decrease the volume of current at the first instant of contact and also reduce the amount at the final break. This diminishes sparking at all points.

All leads are held in the contacts inside the controller by screw connections and are led out at the back of the case where they are protected by a box with a removable cover. Below the controller a connector is inserted in each wire, except those terminating at the local switchboard, to facilitate testing and repairs. The local switch-board carries the circuit breaker, two double-pole armature and two field switches, two discharge resistances, and one ammeter double-shunt. One single-pole circuit breaker is in the positive side of the generator armature circuit near the controller, and is operated by two rods extending through the turret platform; one closes the circuit breaker when pushed down, but is returned to its position by a spring when pressure is removed. The second rod when pushed down opens the circuit breaker and is similarly returned to position by a spring. The shunts consist of two resistances mounted end to end on a fiber base, the current entering between them, dividing, and passing to the separate armature switches for the individual motors. They are used in connection with ammeters located on the mantlet plate beside the controller.

The ammeters are zero center reading, necessary because they are in the armature circuit where the direction of the current is reversed by the controller. The leads between the shunts and the ammeters consist of flexible cord, and *each must be used with the ammeter with which it has been calibrated.* Below the shunt are shown two double-pole armature switches for each

motor, and under them are two smaller field switches with a special contact for the field discharge resistances located near them. Each of these latter switches controls the field of one

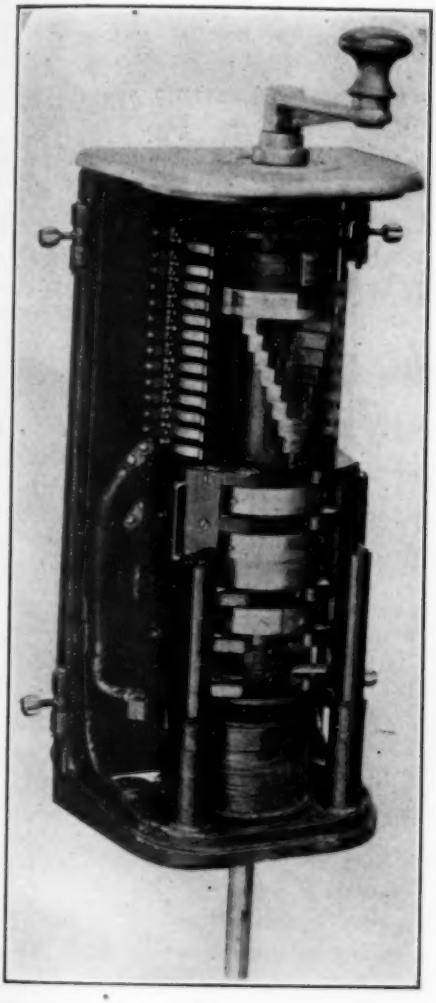


FIG. 146.—Latest design of controller for turret turning. P-10 type.

motor, the main field current dividing before entering them. One of the resistances is connected between the long clips of each of the field switches, and its office is to supply a path for the dis-

charge of the field when the switch is opened and prevent the arc of self-induction. This is accomplished by causing the blades which connect to the motor field terminals to come in contact with the long clips just before breaking the feeding circuit; the field discharge then passes through the resistance. When the switch is closed the blades must be forced in to be free of the long clips or a current will pass through the discharge resistance which will burn it out.

If it is desired to run with only one motor the armature switch of the other can be opened.

The field excitation for both generator and motors comes from the positive side of the power bus-bars entering the generator and motor field switch; both fields are, therefore, separately excited. The inner blade connects to the positive bus-bars and feeds both generator and motor fields.

The middle blade is in the return motor field circuit and has an extra set of clips above which connect with a resistance to take the discharge of the motor fields in a similar way to the field switches for the turret.

The outer blade connects on the upper side with the generator field rheostat connecting to the controller and at the lower side to the bus-wire on the back of the main switch-board, and thence through the generator shunt-field switch to the generator field.

The P-10 Type of Controller.

The controller is shown in Fig. 146 and is much the same in construction as the P-2 except in the arrangement of its fingers and contacts.

In Fig. 147 is shown a diagram of the system of connections for operating the turrets of the *Connecticut.*

In tracing the diagram which shows the present method of connections for energizing and controlling the two motors used for each turret of the balanced type, whether 12-inch or 8-inch, the connections will be seen to be separable into three sections: The starting panel for starting the motor-generator, the motor connections, and the controller connections.

The Starting Panel.—The starting panel controls two sets of connections by two switches, a motor switch for starting the motor of the motor-generator, shown to the left, and an arma-

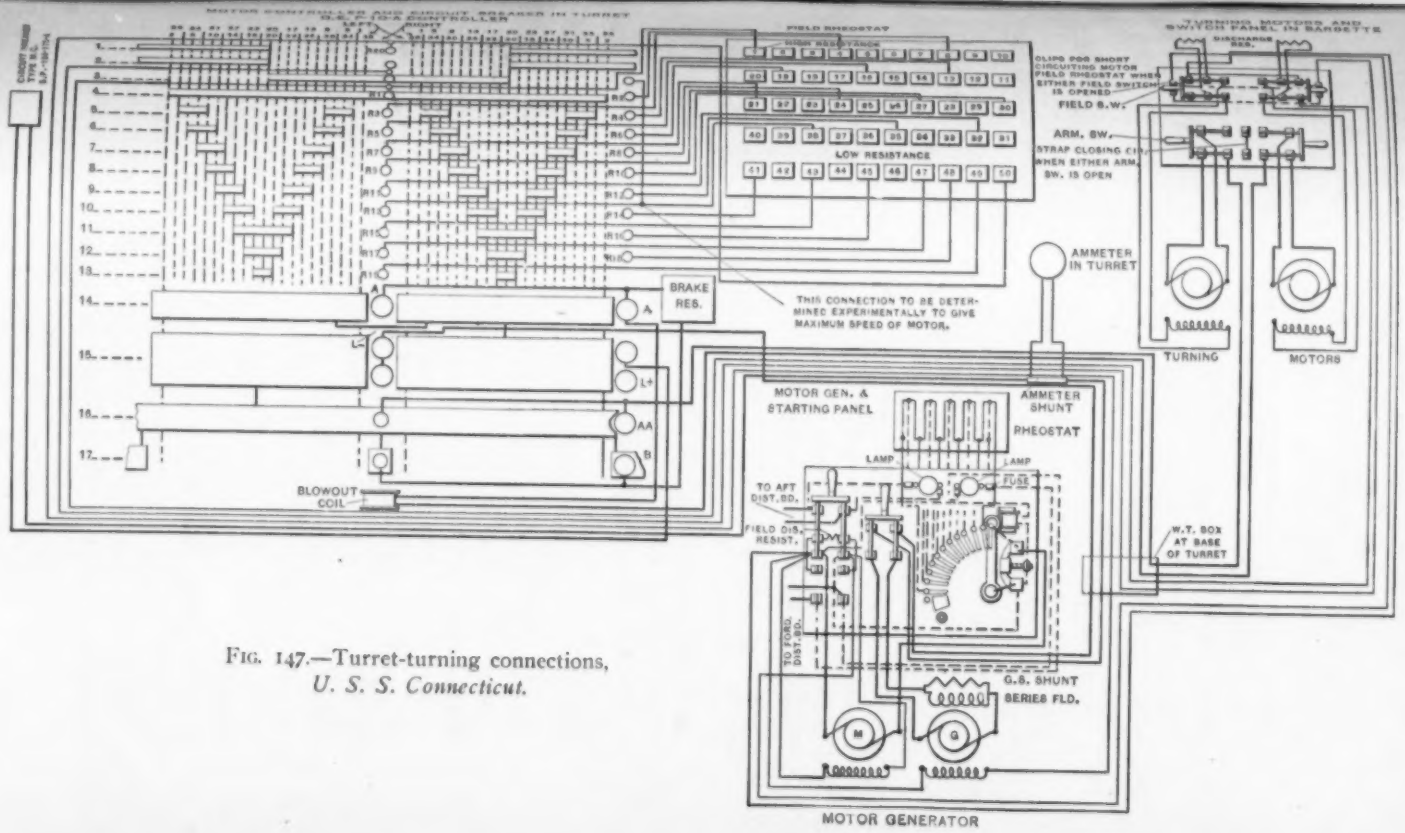


FIG. 147.—Turret-turning connections, *U. S. S. Connecticut.*

ture switch, for connecting the armature terminals of the dynamo of the motor-generator to the controller and the two turret motors; this switch is shown to the right of the former switch.

The motor switch is a double-pole, double-throw knife switch, hinged, and making two sets of contacts on two blocks; when this switch is thrown up the supply is received from the ship's after-distribution board; when it is thrown down, the supply comes from the forward-distribution board.

The upper contacts of the upper throw, and lower of the lower throw, are short-circuited through a high resistance to break the spark; as shown by the dotted line, lamp, and fuses. These contacts supply five circuits, as shown:

I. The circuit for the starting of the motor-generator, as the left blade of the switch has its hinge-block connected directly to one brush of the motor of the motor-generator, while the hinge-block of the right blade connects (heavy dotted line) to the hinge of the lever of the starting rheostat. This starting rheostat is of the general no-voltage-release type, the resistance connections, and lever spring for throwing the lever to the "off" position being shown. No overload device is contained, overload being provided for in the circuit-breaker which closes the supply line at the after (or forward) distribution board.

II. A circuit running to the switch of the turret-turning motors to supply their fields.

III. A circuit supplying the fields of the motor of the motor-generator, this circuit being merely a connection to the hinge of each switch blade and hence keeping this motor's fields at constant, unvarying potential.

IV. A circuit supplying the shunt field of the dynamo of the motor-generator but connected through the variable resistance effected by the controller and by which the field of the motor-generator dynamo is varied at will, and consequently the potential at the terminals of its armature.

V. The circuit of the magnet coils of the no-voltage-release magnet.

The motor-generator switch is merely for closing the connections of the dynamo terminals of the motor-generator with the controller, one lead having an ammeter connected in, the ammeter being located in the turret.

The Motor Connections.

The motor armature connections from the controller lead to a double-pole, double-throw knife switch for each motor which, when closed, as shown in the diagram, *connect the motors in series with each other, which is the method of connection intended for usual operation of the motors;* should it be desired to operate but one motor to turn the turret—which is sometimes practicable—the switch of the motor which is to be cut out is thrown to close the contacts of the "strap-closing circuit when either armature circuit is open"; either motor can be thus used as desired. *There is no device for operating the two motors in parallel. Either or both can be used at will, but if both are used they are always in series with each other.*

[NOTE 24.—Apart from the improvement of the gear train between the motor and the turret, the foregoing shows the two great improvements between the systems of the *Brooklyn* and *Kearsarge* and the systems of recent date, the use of the motor-generator, and the connection of the motors in series.

Motor Generator.—The whole duty of one generator is required for the operation of a Leonard system of control for one set of motors and that generator must also have an especial device for reducing the series field. For a six turret ship six generators would be required for turret-turning alone, not to mention others in case the Leonard system is used for gun elevating.

This is now met by installing motor-generators for the Leonard control systems, the motors taking energy directly from the bus-bars of the main switchboard. The generator field connections of the motor-generator can then be made adjustable to the system of control and the main generators in the dynamo room can be large units, can feed their total output to the bus-bars, can be kept to their normal machine connections, and can mutually assist by paralleling. Furthermore, it lies within the design of the motor-generator to supply to the motor its available overload capacity of at least 50 per cent in emergency, the effect of overload drive falling to the dynamos of the motor-generator, but less serious in its consequences when distributed to the bus-bars than if for single main generators of the dynamo room.

Series Connection.—The effect of connecting two motors in series is that, while each will be able to take its full load current, the voltage impressed at the terminals of each motor will be only half that of the supply line—half the voltage the motor would receive if it were connected singly to the line, or in parallel with the other motor—the effect of the half voltage being to practically halve the motor speed, and at the same time to develop a large torque at the reduced speed. This large torque at low speed is

well illustrated by the curves of (Fig. 148) constructed from experiments made by Prof. C. P. Steinmetz on railway motors when operated in series and in parallel. Comparing the torque for a speed of 100 r. p. m. when in series, it will be seen that equal torque requires a speed of over 700 r. p. m. when the two motors are connected in parallel; applied to a turret it illustrates that desirable slow speed with good driving torque is attainable by connecting the motors in series. A paralleling device is not necessary as sufficiently higher rates of speed can be provided for in the controller by weakening the motor fields.

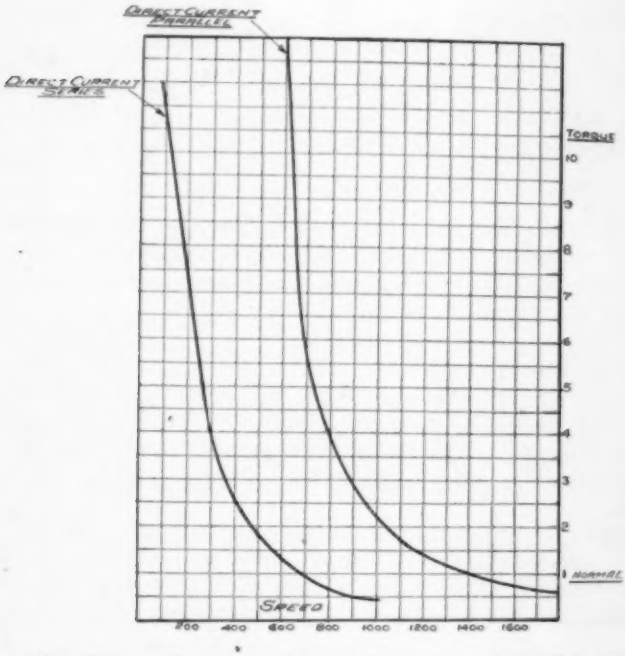


FIG. 148.—Curves of torque and speed for series and parallel connection of two motors.

In the tests of the *Brooklyn* and of the *Kearsarge* and *Kentucky* the factor of high rate of speed for extreme train predominated; this is shown in the specifications and the test results of 70 seconds for complete train in the former case and 58 for complete circle (360 degrees) in the latter as calculated from an extreme train in 53.4 second. The *Brooklyn's* forward turret was started and stopped 37 times in the peripheral distance of one inch, but the test was made rather as a comparison with the steam driven turrets; in the case of the *Kearsarge* the slowest practicable speed was about 30 degrees of arc per minute. Present specifications require a maximum training speed of only 100 degrees of arc per minute, a reduction of 3.6 : 1 as compared with the *Kearsarge* tests, but they also require a

minimum training speed of six degrees per minute or one-fifth of that formerly attained.

The reduction of speed, fineness and steadiness of slow control, is necessitated for better fire control and the increased ranges of target.]

The motor field connections have a double-pole, single-throw, knife field switch installed on the board with the armature switch. The hinges of the switch blades of each motor connect its field. When closed on the outer contacts one blade is connected in circuit to the motor switch of the motor-generator starting panel; the current comes out by the other blade (for the left motor) to the opposite contact, it is connected back to the opposite pole of the motor switch on the motor-generator starting panel through two "clips for short-circuiting motor field rheostat when either field switch is opened," the clips being connected; in this connection for the right motor a connection is made to the controller for the purpose of introducing a resistance in the motor field, as later explained. The short-circuiting clips are used when only one motor is operated. A pair of contacts on each switch introduce a high resistance across the field terminals. The contacts 3 to 13, inclusive, are the only ones connected to resistances, excepting that the low resistance No. 50 is switched in on contact 1 at position 20.

The Controller Connections.—The connection from the left-hand side of the motor-generator armature switch passes to and through the water-tight box in the turret base to the circuit-breaker, the ammeter being installed on this lead. From the circuit-breaker the lead runs to one set of two fingers, the two connected, of contact 15; this is the positive lead to the controller from the armature of the motor-generator. The negative lead goes via the water-tight box in the turret base direct to the other two fingers, connected together, of contact 15. Hence, the two pairs of fingers of contact 15 are the positive and negative terminals of the controller cylinder for the turret-motor armature leads.

The different functions of the controller are traced as follows:

I. *Connection of Armature of Dynamo or Motor-Generator to Turret-Motor Armatures.* II. *Reversing Switch.*

As has been pointed out the motor-armature switches connect the motor armatures in series.

The two fingers of contact 14 are connected together, and circuit is made to and through the blow-out coil and thence to the armature switch of the right-hand motor; thence through its armature back to the other pole of its switch; to the switch of the left-hand motor, through its armature; back to its switch, and thence to the fingers of contact 16. Contact 16 is a continuous conductor and is connected to the left part of contact 15. Hence, if the controller is moved to any position on the right, the current can flow from the right part of contact 15 through its connection to the contacts of 14 (connected together); thence to the motors and back to the left part of contact 15, which is the negative terminal of the controller cylinder; if the controller be moved to the left the direction of the current will be reversed since the right part of contact 15 will connect with the negative terminal of the controller. This set of connections, therefore, accomplishes the action of a reversing switch also.

III. *Varying the Voltage of the Field of the Motor-Generator Dynamo.*

The connection for the shunt field of the dynamo is a circuit from the hinge of the motor switch of the motor-generator starting panel to and through the dynamo field; thence through the water-tight box in the turret base, to a connection for the finger of contact 1, this being connected to $R50$; the return circuit is through the resistances to $R1$, which connects to the left finger of contact 4, the finger touching this contact for all positions of the controller; from the finger of block 4 a circuit leads by way of the water-tight box in the turret base to the clips of the turret-motor field switch and thus forms the connection for the other leg.

If the controller is moved to the right block 4 makes contact on the finger $R2$, then on $R4$ and so on, each time cutting resistance out of the dynamo-field circuit, increasing its armature voltage, and consequently the speed of the motors, as all the contacts, 4 to 13, inclusive, are connected together. This continues until position 20 is reached, when contact 3, electrically connected to 4, comes in contact with the finger above $R2$ (not marked) making a connection by which all the resistances are cut

out and the dynamo field has no resistance in circuit; the dynamo armature is, therefore, developing its greatest voltage, and the turret motors their *maximum speed for constant excitation.*

IV. *Varying the Field of the Turret Motors.*

A lead from the motor switch of the motor-generator starting rheostat leads to the turret-motor field switch for each motor and through the clips back to the negative pole of that switch; hence the motor fields are excited at the full voltage of the supply line as long as this condition remains undisturbed. On the field switch of the right motor is connected a circuit which leads via the water-tight box in the turret base to the connection to contact 4, and from the clip of the same switch leads a connection, also via the box in the turret base, to a connection between the fingers of contact 2 and contact 3. When, therefore, contact 2 has made contact with its finger the constant excitation from the starting panel is short-circuited, but the motor fields are not deprived of current because contact 1, electrically connected to 2, comes in touch with finger *R*20 and the motor field receives current through the high resistances as determined by the contacts 4 (and 3) to 13, inclusive; being so arranged as to cut in resistance as the controller cylinder is moved on, the motor fields are further weakened, causing the motors to speed up.

To prevent an excessive resistance from being cut into the motor fields, the short-circuit in passing from position 20 to position 21 is made adjustable to that desired and the resistances numbered 49 and 50 are used, being low and but little in excess of that of the former line for constant excitation.

V. *Action at the "Off" Position* (Fig. 147).

From the finger of contact 14 is a circuit through the brake rheostat leading to the two fingers of contacts 17, which, in this position, cover their fingers. Contact 17 is connected with 16, from which a circuit leads through the armatures of both turret motors as described in I above, hence this forms a short-circuit and one of low resistance; if, after the controller is in this "off" position, the turret motor armatures should continue to revolve they would generate an electro-motive force through this

low-resistance circuit, their fields being still separately excited, which will exert a strong counter effort and stop the motors and turret.

VI. *Résumé of Important Positions* (Fig. 147).

"Off" Position.—In this position a short-circuit is formed through the brake rheostat and motor-armature circuits, producing a strong effort to stop the turret should the motors continue to revolve through inertia. The motor fields remain excited at supply line potential.

Position 1.—All resistance is cut in the dynamo field circuit. Motor fields are excited as before.

Position 9.—Resistances Nos. 50 to 27 remain in the dynamo field circuit. Motor fields are excited as before.

Position 19.—Resistances No. 50 and No. 49 remain in the dynamo field circuit. Motor fields are excited as before.

Position 20.—No resistance remains in the dynamo field circuit, and the motors are at their maximum speed at constant excitation. The motor fields remain excited as before.

Position 21.—No resistance is in the dynamo field circuit. Resistances Nos. 49 and 50 have been cut into the motor field circuit, weakening the field, the motor, therefore, speeds up.

Position 26.—No resistance is in dynamo field circuit. Resistances No. 41 to No. 50 have been cut into the motor field circuit, and the motor attains higher speed than in positions preceding.

Remaining Positions.—The connections for the remaining resistances, 1 to 41, inclusive, to be gradually cut into the motor field circuit to still further increase the speed are determined by experiment; the dynamo field being without any resistance in circuit.

DISCUSSION

Sabre and Bayonet.

(See No. 120.)

Lieut.-Colonel Wm. F. Spicer, U. S. M. C.—In the following lines, the writer does not pretend to criticise Civil Engineer Cunningham's manual of the "Sword and Bayonet," being himself not an expert, like the author, in the use of either weapon; but rather to point out in this work, what appear to him to be certain features that have been needed in the service, as well as to call attention to one or two details that might be made a little more definite in the text, and to suggest the addition of several other parries and attacks with the butt and muzzle of the rifle.

In the first place, let us acknowledge and be thankful for the fact that the author has had the temerity to break away from and ignore all foreign and technical words in his manual, and to substitute therefor simplicity of construction. How utterly perplexing and discouraging are such complicated terms to the beginner, any one may recall, who has gone through with any such instruction—particularly with that of the foil. And they have heretofore been such a firm fixture in all manuals on the subject that the Anglo-Saxon can scarcely be said to possess one that is written entirely in his own language, free from borrowed words.

The simple right or left, high or low attack and defense are all that one needs to learn, for military purposes. Once well grounded in these, practice develops that subtle intuition which carries with it the instant reply of hand and eye that the expert acquires, and which is akin to what may be considered the reflex action that the expert wing-shot possesses and unconsciously employs without ever looking at his sights.

Simplicity of detail is what has been needed for a quick acquirement of any manual, for military purposes, practice will do the rest. In the sabre manual a notable improvement is the resting the left hand on the hip, which is less fatiguing than is the old position of the hand behind the back, and is the method of probably one of the best English swordsmen.

It would be interesting to know how many swordsmen have profited (or more correctly, perhaps, have come to grief) by observing the old maxim, "Watch your opponent's eye." It has always seemed to me to be the very best way in which to miss his intention, and has no doubt been the cause of many a slip up in parrying. In this instance, the author has shown himself to be somewhat of an iconoclast, by throwing down this ancient image and substituting therefor plain, practical observance of physical cause and effect. By all means "Watch carefully and constantly your opponent's sword and sword arm; do not watch his eye" (unless you are a

mind reader, or are bent on furnishing a funeral), and trust to your sense of touch, or "feel," of his weapon, as well.

The lunge.—Here the author has recognized a perfectly natural principle in prescribing the position of the foot, "Behind the knee," to facilitate a quick recovery to guard. The position advocated by some, of keeping the lower leg perpendicular over the instep, is wrong and contrary to what nature dictates and instinctively does in the effort to spring back quickly, namely, a slight preliminary pushing forward of the knee to give a more powerful impetus to the recovery. By keeping knee in front of foot, you are already in position for this. "The left foot remains flat and in place." This is a feature too often overlooked, especially in the bayonet exercise, in reference to the right foot (which is then in rear). How often have we seen the foot in rear tilted up on edge in making a lunge, rendering this position insecure for and disastrous to a quick recovery to guard?

A thorough drilling (at first without arms) in recovering from the lunge, acquiring the habit of "pulling," so to speak, with the foot in rear,—sole flat on the ground thus making it do its share in the recovery—is a most necessary feature in sword and bayonet exercise. It is fatiguing, very much so, but once thoroughly acquired and the muscles of the leg hardened by it, one becomes as agile and as quick as a cat.

With the advent of the modern service sword, in its legitimate condition, that is, sharp (which is, after all, only a reversion to ancient times), including the false edge, or part of back of blade, the cuts delivered in a quick, snapping motion, as stated by the author, are all that is requisite. And he states very truly that the old swinging cuts, though they may be advantageous at times, with a sure opening, seem only to indicate to the opponent just what to expect because the interval of time, however short it may be, in making such a cut, is fully enough to warn a good swordsman.

THE BAYONET EXERCISE.

Here an improvement first strikes one in the position of the feet in "guard." The right foot back about once its length is the position that nine men out of every ten naturally assume. On drill, one hears the instructor continually cautioning men about the right foot. (That is, referring to the old manual, which prescribes that the right foot is twice its length in rear of the left). Few men will keep this distance unless they have been drilled at it for a long time. Look at Privates Smith, Jones, Brown, Robinson. All have the right too close to the left, and why? It is beause the position as heretofore laid down is a constrained position, and they bring up the right foot in order to obey the demand of the body for a natural poise, free from strain on the thigh muscles, but with the foot once its length in rear, the position of guard is a natural one in which a more complete control of the muscles is obtained.

Grasp of hands on the piece.—The left hand "grasp is firm but always ready to shift." This is as it should be. In the old drill, where the left hand holds the piece with thumb extended along stock, the grasp is anything but firm, and a quick and vigorous parry of your opponent's right

low thrust (attacking your left side) or his sudden push of your bayonet to your right, would demonstrate the insecurity of such a grasp, but (judging from the illustrations) with the left thumb around the piece, the grasp of the left hand is always firm.

Barrel to the left.—This position of the piece is not only the best for the sword bayonet, but it gives additional support to the right hand, in making a thrust or lunge, because the flat of the butt-stock against the under side of the forearm is a decided advantage.

The suggestion is submitted that it may not be good policy to employ two different ways of changing guard, namely, making a strong sweep of piece in turning (if clear of friends), and raising the piece vertical (if near friends). Might not these two motions become momentarily confused in the mind, at a critical period in an engagement, and give the opponent an advantage of which he would not be slow to avail himself?

Butt to front.—"Bring the piece to vertical in front of shoulders, etc." "Strike forward and upward with right hand." This seems to indicate two motions in making this attack, whereas the full force of this blow lies in its being made in one quick swinging motion upward and forward, directly from guard, striking the opponent in the abdomen or breast with toe of piece. The loss of time due to first bringing the piece vertical, might prove disastrous, in defeating this very powerful blow. That this was the intention of the author of the bayonet exercise (Gen. Upton) in use formerly in the service, the undersigned has reason to know from correspondence on the subject, in relation to this particular attack with the butt. And yet almost universally he has seen men instructed in the opposite way simply because the wording of the drill book was too pedantically followed. No doubt the author of "Sabre and Bayonet" would himself execute this attack in one motion, but it is suggested that the paragraph descriptive of it be changed so as to indicate but one motion (provided, of course, that it was his intention to so execute it).

Another powerful attack is obtained (in case the "butt front" be successfully parried), in making the recovery of "guard" an attack in itself, by bringing down the, bayonet or muzzle forcibly on the opponents head, thus: use the left hand as the fulcrum (the thumb must be *around* the piece for this, pull back strongly with right and push with the left. This gives a smashing blow, and here is wherein the flat of the butt coming against the forearm, helps greatly to retain control of the piece, should the blow fail or miss. (This must be well nigh impossible if the method in vogue is followed of keeping barrel slightly "inclined to the left.")

The same may be expected in "butt right" and "butt left," except that the attack with the muzzle in recovering "guard" from "butt right" is not so effective as that from "butt left."

Butt parry (omitted from recent manuals) is an effective and a very quick parry of the low left thrust, and is made by carrying the toe of the piece with right hand outside left knee, keeping the bayonet still in the normal position and turning barrel to right. This throws your opponent's bayonet forcibly to your left and exposes him to a blow from "butt front," which can be executed with a quick step forward or a lunge.

Butt parry to right, same (and barrel being already to left, the butt is in right position for this without having to be turned). In place of the "butt front" from these parries, a counter attack may be delivered by a thrust from "short guard."

To meet and parry a blow from the "butt front" swing piece to horizontal position across body, and bear down with left hand, then swing right hand and butt upwards, striking opponent on left temple with toe. If too late for this, then you are in position to parry his return blow with muzzle, on your head, by raising both arms, and you are still in position to swing your butt inwards and attack his head.

A good attack with the butt may be executed from a left parry, thus: parry and force opponent's piece to that side. Keep a continuous swing of the butt toward your opponent, stepping forward at same time with right foot, and striking him with toe of piece either on left temple or over the kidneys. In fact there are several good attacks with the butt, and a system of "butt fencing" is a good thing to know when a man is closely pressed, and there is no room in which to use the bayonet.

One important thing should be impressed upon everybody who is likely to instruct men in bayonet exercise, and that is, the intense fatigue felt in the arms and shoulders by being kept long in the position of guard. No one who has gone through with this drill can ever forget it; and likewise, no one who never had much of it can ever remember it sufficiently to feel compassion for men under instruction. Watch the men on drill some time when opportunity offers. In nearly every case you will see them standing in the position of "guard," while the instructor goes through with a lengthy explanation of the movements to be excuted. In the meantime the men are striving to overcome the pain in the arms and thighs, without committing themselves—and you see it plainly then, when the long-delayed command of execution finally comes, the strength to execute the motion properly is gone, and the instructor (himself intensely interested in the exercise), commits the folly of causing repeated execution of the already explained motion, just when the men are in least condition to do it. Too much emphasis cannot be put upon this too common fault. Let your men stand at "order arms" during explanations and actual illustrations by the instructor (and it goes without saying that the instructor himself should be somewhat of an expert at this), and then when you put them through the exercise their muscles are fresh and their attention is not handicapped by aching arms.

Bayonet drill in itself approaches somewhat a violent exercise, if it is done honestly—that is, with life and vigor and snap put into every motion, and the weight of the piece counts tremendously; and as men in the service are drilled, say once or twice a week on an average, at bayonet exercise—rarely oftener, they do not acquire that complete control of the piece, and disregard of its weight, that come only with a thorough daily drill, after which the muscles of the arms and hands become so strengthened that the rifle seems to have no weight and can be easily held at guard in the right hand alone. Therefore, do not make explanations with the men standing at "guard." Keep them fresh—their attention will be all the

better for it. Be able to execute the motions yourself in the most accurate and vigorous manner. No amount of explanation will ever teach men to make a vigorous or a vicious thrust with the bayonet, or a blow with the butt. Once they see their officer do it well, it becomes to them a far different matter and it will infect the company.

The above lines are written in pursuance of a recent conversation with the author of "Sabre and Bayonet," when the writer was courteously invited to express in writing his views on the subject, and more especially to cite certain parries with the butt of the rifle, which had been omitted from service manuals; and in submitting the above he desire to thank the author for the compliment implied, and hopes that these lines may be acceptable to him.

Civil Engineer A. C. CUNNINGHAM, U. S. Navy.—Colonel Spicer's discussion of the paper on "Sabre and Bayonet" has unusual value in coming from an officer who has not only given much study to the subject, but has also seen and been connected with its practical working amongst enlisted men. The colonel's appreciation of the author's desire to advance a military art that has but few friends, at the best, has given his discussion a very kindly tone, but it is none the less thorough on that account.

In the matter of naming the lines of attack and defense as right and left, high and low, no violence has been done to the art of fencing, but in reality a kindness; in the original names of the lines, tradition has it that they represented the consecutive positions which a sword most naturally took. "Prime" was considered the position to which a sword most naturally came upon being drawn from the scabbard; then followed seconde, tierce, quarte, quinte, sixte, septime, octave. (Fellow swordsman, did you ever hear of them all and can you place them now?) These names, of course, are merely the numbering of the various positions, but to an American they sound much more formal than would one, two, three, four, and so on. Their fundamental defect is that they relate to a position, but do not in themselves describe it.

When one has learned the ritual and mastered the application of a "mysterious" and skilful art it is human nature to consider one's self superior to the unlearned majority and to perpetuate the existing conditions. To know that what one may have been years in learning might have been understood, even if not perfected, in as many days, is not easily acknowledged. To place such an art in practical form and reduce its ritual to a few simple words is not likely to meet with the approval of experts, on the start, but it will no more injure their calling than the kodak has injured the professional photographer.

In a sabre manual the condition governing the position of the left arm and hand is principally one of having them out of danger. When a beginner is hard pressed in an assault he will instinctively cringe and cover the left part of his body with his left arm; this is unsightly, and the position with the left forearm across the back is the farthest removed and the most likely to prevent it. In a military combat this position would seldom be taken, especially as the scabbard would most frequently be held in

the left hand. It should never be forgotten, as well, that in a desperate case a cut may be taken on the left arm at the same time that a fatal thrust is delivered in an adversary's vitals. Some expert duellists have come to an untimely end at the hands of novices by forgetting this fact.

The long reaching and rapid lunge which it is sought to develop in the fencing hall on a resined mat, in loose clothing and flat-soled shoes, would be a most disastrous undertaking in the field and it is not even necessary in the fencing hall. There are other ways of quickly and effectively closing distance by advances, closures, passes, and jumps. When these closures are made with a shout or yell at the same time, many an opponent will be startled into receiving a hit.

In the matter of changing guard to the rear in two ways, one by sweeping the piece and the other by bringing it vertical, the author was principally concerned with the manual as applied to individuals. The extended study and experience of Colonel Spicer show that the vertical change is unquestionably the one in which the pupil should be grounded. In the butt to front the author's intention was that the execution should be a continuous motion. The butt to front may, in fact, be executed from many positions and in many ways with which it would not be desirable to encumber a manual but which would soon be discovered by an intelligent enlisted man in practice assaults.

The further remarks of Colonel Spicer on his original developments of the use of the butt in attacks and parries are earnestly commended to those to whom this subject may be of interest and value. They would be most valuable in a melee and would be almost sure to rapidly succeed point and edge work in an encounter between equally determined enemies.

To those who have read "Sabre and Bayonet" it will be entirely evident that the author's principal concern was the development of the individual. The comprehensive application of the matter to troops and seamen can only be made by officers who, like Colonel Spicer, are in a position to judge of the results. Individual development can not, however, be neglected and should certainly be encouraged.

For mob attacks on an individual the short guard is of the greatest value and should be emphasized in that connection. With quick changes of guard and such kicks to the rear at the height of the knee of a man might readily deliver with his right foot, it is safe to say that a skilful man would put several "toughs" out of action before being overpowered.

For making bayonet exercise popular amongst enlisted men the "broom fight" can be most highly recommended. The men are padded as for regular practice assault, sparring gloves being preferably substituted for the ordinarily padded fencing glove. The men are armed with ordinary corn brooms and make the assault using only the broom end for striking and thrusting, but parrying also with the handle. An umpire is desirable in these bouts.

The activity, skill, and originality that will be developed by these "broom fights" will be surprising, and the interest of the onlookers will only be equalled by their desire to join the game.

The Voyage of the Dewey.

(SEE NO. 120.)

J. D. WOOD, Late Sailing Master Dry Dock Dewey.—The voyage of the dry dock Dewey to the Philippine Islands has been the subject of several excellent newspaper and magazine articles, also official and unofficial reports, therefore, it seems barely possible that anything remains to be explained. However, judging from an article in the December number of the PROCEEDINGS by Lieut.-Commander Bennett, who was executive officer of the *Glacier*, a misapprehension appears to prevail which is unfair to the crew and the sailing master, and which I shall not attempt to defend with any other motive than that of showing the confidence in us was not misplaced and that the duty was faithfully performed, as results would seem to indicate.

It is generally admitted, even by Mr. Bennett, that work on board the dock was unique and difficult. This criticism was mortifying to those who had it to perform. I am speaking particularly of the two mates and twelve seamen. While at sea these men measured up to the fullest requirements, which was indeed trying and required physical force and skill which no Chinese crew, as has been suggested, could have accomplished. They were big Scandinavian sailors with plenty of brawn and brain and were frequently complimented by Commander H. H. Hosley, commanding the expedition, for their good work at sea.

It is true, as Mr. Bennett states, that in port the best of these men would get on an occasional drunk and overstay shore leave, as did the white crews of the *Glacier* and *Potomac*. This is nothing new in deep-water sailors, to obviate this trouble some ship masters discharge the whole crew, upon their arrival in port, and place watchmen on board. We hired men from shore to take their places, temporarily, for which the absentee's pay was docked sufficient to pay the substitute. This was about the greatest punishment that could be inflicted, except to place them in jail through the American Consul. This action the consul disapproved, stating that these men had been a long time at sea and such punishment would be unjust.

I wish to call particular attention to the fact that merchant seamen, as these were, cannot be dealt with as enlisted men of the regular Navy, and the man who tries to do so will soon find himself in serious legal complications.

Several of these men, at Las Palmas and Singapore, applied for their discharge, claiming excessive and laborious work as the reason, which was granted in a few cases for the good of the expedition and only when as good or better men could be secured to fill their places. The six additional seamen authorized at Las Palmas were indeed a great help. The Chinese crews of the *Brutus* and *Caesar* were very orderly in port for which they are to be commended, but they would not have suited to man the dock.

The towing gear broke and the dock was adrift six different times. This gear weighed several tons and the means of getting it was crude,

especially when the sea was rough, which was always the case and was the cause of going adrift. It was gotten aboard and repaired by the crew of the dock. There were several thousand screw bolts in the connections which were continuously working loose, caused by the motion of the dock and required the services of four men constantly to keep them tight. This work could not be neglected as the least lost motion, or wiggling, would wear the holes bigger and the bolts smaller. Some of the horizontal connections showed signs of serious strain in the Atlantic Ocean and were reinforced by several fish plate connections by the crew of the dock which took it safely into Las Palmas. The preservation of the dock was no small item. The navigating, watching, and signalling was maintained at the highest standard. The whole voyage was replete with care, anxiety, and hope. The disadvantages, the heavy awkward work, the leisurely criticism voluntarily given, certainly made life unpleasant on the Dewey. Just here, I wish to state that I have probably handled more ships, towed more vessels and other craft under unfavorable conditions than all the other officers and men of the Dewey flotilla combined, notwithstanding their creditable experience. My experience covers nineteen years of the most difficult work known to the profession without mishap or accident. I offer this to Mr. Bennett as an apology for not being an ideal "forceful ship-master." Should unkind critics prefer to credit my nineteen years' success to stupid luck rather than to good judgment, I have no serious objection.

The crew of 36 men were of an unusual combination and necessarily so by reason of the unusual undertaking. With a few exceptions they performed their work willingly and well. The Bureau of Navigation is to be congratulated upon the organization of the crew, anticipating every contingency that did arise with nothing surplus. It was the conceptions of master minds in the greatest undertaking of its kind the world has ever known. I refer to our splendid Navy and its ability with pride and enthusiasm. I am too full of hope and determination to be useful to be troubled about Mr. Bennett's opinion. If my services contributed a fractional part to the success of the Dewey expedition, I am perfectly willing that the credit should be divided up among my critics.

Referring to Commander H. H. Hosley, U. S. N., commanding the expedition, while he is not in need of any praise from me, I wish to state that to his cheerful energy, fair dealings, and excellent judgment, all credit and success is due. He kindly said in regard to my work in his official report to the Chief of Bureau of Navigation: "The sailing master of the dock had a unique and difficult position to fill which he successfully did under very trying circumstances."

PROFESSIONAL NOTES.

Prepared by Professor PHILIP R. ALGER, U. S. Navy.

SHIPS OF WAR, BUDGETS, AND PERSONNEL.

AUSTRIA.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Erzherzog Ferdinand-Max.	10,600	Trieste.	Building.
Ersatz Tegetthof	14,500	—	Projected.
Ersatz Kr.-Rudolf	14,500	—	"
Ersatz Kr.-Stephanie	14,500	—	"
Scouts.			
Ersatz Zara	3,500	—	Projected.

1907 PROGRAM.—The *Moniteur de la Flotte* states that during 1907 three 14,500-ton battleships will be begun, to be of 20 knots speed and carry four 12-inch and eight 9.5-inch guns. A scout ship of 3500 tons, with turbine machinery to give 26 knots speed, is also to be laid down.

ARGENTINE REPUBLIC.

The government has adopted a new naval program, covering the construction or purchase of 3 armored ships, nine torpedo-boat destroyers, and 21 torpedo-boats, at a total cost of 145 million francs. Besides this 45 million francs are to be spent on gun-boats and transports. Two of the armored ships will be the armored cruisers of 10,000 tons and 22.5 knots speed now building for the Italian government at the Orlando and Odero works. As is known, the Argentine government purchased in the same manner, during the years 1895 to 1900, from the Ansaldo and Odero works four armored cruisers, of the type *Garibaldi*, which have proved very efficient.—*Le Yacht.*

BRAZIL.

The Brazilian Government has placed the order for a *Dreadnought* battleship with Messrs. Vickers, Sons, and Maxim, at Barrow. She will be the largest vessel ever built by the firm, and will be 500 feet long, with 82 feet beam, and will mount ten 12-inch guns, several guns of smaller caliber, and many quick-firing guns, and will be fitted with submerged torpedo tubes. This battleship will be one of the most powerful afloat when she is launched, and will embrace many new departures in warship construction. —*Pages Weekly.*

FRANCE.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Démocratie	14,865	Brest.	Under trial.
Justice	14,865	La Seyne.	Launched Oct. 27, 1904.
Vérité	14,865	Bordeaux.	Building.
Liberté	14,865	St. Nazaire.	Launched April 19, 1906.
Danton	18,350	Brest.	Ordered.
Mirabeau	18,350	Lorient.	"
Voltaire	18,350	Bordeaux.	"
Diderot	18,350	St. Nazaire.	"
Condorcet	18,350	"	"
Vergniaud	18,350	La Seyne.	"
Armored Cruisers.			
Ernest Rénan	13,644	St. Nazaire.	Launched April 9, 1906.
Jules Michelet	12,550	Lorient.	" Aug. 31, 1905.
Edgard Quinet	13,644	Brest.	Building.
Waldeck-Rousseau	13,644	Lorient.	"

THE NEW BATTLESHIPS.—Last April, in accordance with the vote of the Chambers, it was decided that six battleships of 18,000 tons should be laid down during 1906, instead of three, as already proposed in the estimates. Two of these, the *Danton* and *Mirabeau*, are being built at the government yards at Brest and Lorient, respectively, but delay occurred in placing the contracts for the other four ships, the *Voltaire, Diderot, Condorcet,* and *Vergniaud,* the government being undecided as to whether to adopt the turbine system in the new ships or not. The question has now been settled in favor of turbines,* and a ministerial decree has been issued directing the laying down of these four ships in private yards; the *Diderot* and *Condorcet,* at the Chantiers de la Loire, and the Chantiers de Penhoët, at St. Nazaire, respectively, while the *Voltaire* will be built at the Chantiers de la Gironde at Bordeaux, and the *Vergniaud* at the Forges et Chantiers de la Méditerranée at La Seyne, near Toulon. The dimensions of the new ships have also been definitely fixed as follows: Length, 475 feet; beam, 84 feet 3 inches; displacement, 18,350 tons, with a mean draft of 27 feet 9 inches. The engines are to develop 22,500 I. H. P., giving a speed of 19 knots, with four screws; the coal supply will be 2010 tons, with a radius of action at 10 knots speed of 8130 miles. The armored protection will consist of a complete belt of hard steel, with a maximum thickness of 10.8 inches, tapering to 7.8 inches at the extremities; the turrets for the 12-inch guns will be protected by 12-inch armor, those for the 9.5-inch guns by 8.8-inch armor. The armament will consist of four of the new pattern 12-inch guns, and twelve 9.5-inch guns, with sixteen 14-pounders, eight 3-pounders, and two submerged torpedo-tubes. All six ships are to be completed within the four years, and the Ministry of Ma-

* The *Moniteur de la Flotte* quotes the Minister of Marine as stating in the discussion of the naval budget: If turbines are not decided upon for the six battleships, the reason is that there are but two French companies who build them. They can supply turbines for two ships immediately; for two others only in three years. ". . . . . The six battleships will be finished in four years. Three will have turbines and the other three reciprocating engines with forced lubrication. In both cases the speed will exceed 20 knots."

zine claims that they will be equal in every respect to the similar class of ships now constructing for other foreign powers.—*United Service Gazette.*

The following additional information in regard to the *Danton* class is taken from *Le Yacht* and *Le Moniteur de la Flotte.* The turbines are to be of Parsons' type, with four screws. The bows are straight, without rams. The 12-inch guns are in two axial turrets, and the 9.5-inch in six turrets, three on each side. The torpedo tubes will probably be for the new 60-cm. torpedoes. The muzzle velocity given by the 12-inch and 9.5-inch guns will be 875 m. s.

NEW SUBMERSIBLES.—The four 800-ton submersibles have been ordered—this completes the series of 20 submarines which were to be laid down in 1906. These 800-ton boats are to have a radius of action of 2500 knots, a surface speed of 15 knots, and a submerged speed of 10 knots.—*Moniteur de la Flotte.*

Orders have been given to remove the torpedo tubes from the French battleships *Brennus, Hoche,* and *Amiral Baudin.—Engineer.*

STEAM TRIALS.—The new first-class battleship *Patrie* has completed her acceptance trials, which have been carried out, after the final opening up of the machinery and its careful inspection at the end of the first series of trials, satisfactorily. The results were as follows: At a three hours' run at full speed, with three-quarters of the fires alight, the engines developed 17,900 I. H. P.—400 H. P. over the contract—giving a speed of 19 knots, with a coal consumption of 171 kg. (380 lbs.); during a ten hours' trial, the engines making 114 revolutions and developing 17,950 I. H. P., a speed of 19.1 knots was maintained, with a coal consumption of 842 gr. (1.85 lb.) per I. H. P. per hour; during one hour of this trial the I. H. P. rose to 19,200, giving a speed of 19.4 knots, being a knot and a quarter over the contract. The Niclausse boilers worked the whole time without any hitch.

These two trials are the first of the kind to which any ship has been subjected in France, the object being to see what the ship could do on an emergency with three-fourths of her boiler power, should the other fourth have been damaged by any accident in war, and the excellent results obtained have given the greatest satisfaction, full credit being given to the great Forges et Chantier de la Méditerranée, at La Seyne, where the ship was built.

The new first-class armored cruiser, *Victor Hugo,* has commenced her trials at Lorient. With the engines developing 7000 I. H. P. at her first trial, a speed of 16.2 knots was maintained; at the 16,000 H. P. trial, the actual I. H. P. developed was 17,500, giving a speed of 20.8 knots.

The new first-class armored cruiser *Jules Ferry* has also made a successful progressive power trial at Cherbourg. The engines developed 27,691 I. H. P., with a coal consumption of 850 gr. (1.88 lb.) per I. H. P. per hour, and 183 kg. (403.50 lbs.) per square meter of grate surface, while a speed of 22.3 knots was obtained.

The new first-class battleship *République* has also completed her first acceptance trials; at a three hours' run with three-fourths of her fires alight (that is in 18 boilers), the engines made 120 revolutions, giving a speed of 18.8 knots, with a coal consumption of 166 kg. (366 lbs.) per square meter of grate surface. During the ten hours' run, with all boilers alight, the engines developed 17,620 I. H. P., with a coal consumption of 115 kg. (254 lbs.) per square meter of grate surface, giving a speed of 18.8 knots. This trial was made under very unfavorable conditions of weather, as it was blowing hard with a heavy sea on.—*United Service Institution.*

The French Minister of Marine stated recently that it was necessary to lengthen some of the docks at Brest, Cherbourg, Lorient, and Toulon, and that the work would be completed before the new battleships were ready. New docks are to be provided at Brest, Cherbourgh, Lorient, and Rochefort. By the same time two docks to receive the large battleships will be constructed severally at Dakar and Diego Suarez. In addition, a similar dock, or, perhaps, a floating dock, will be at Saigon. In relation to the complaint that large submersibles were being laid down without proper consideration, M. Thomson said that the facts were simple. France had maintained her lead in regard to submarine navigation, but she must make progress, and he denied that there was any return to the construction of submarines instead of submersibles. The technical committee, contrary to statements that have been made, has adopted three plans for submersible boats, and not all those that were presented to it. The first is for a boat 196 feet 9 inches long, with 577 tons displacement or 810 tons submerged. The second 210 feet long, with displacements respectively of 530 tons and 628 tons; and the third 183 feet 9 inches long, with displacements of 555 tons and 735 tons. All these will satisfy the conditions imposed with reference to speed and range, the surface speed being 15 knots and the speed submerged greater than in the case of vessels now in existence, while the range is 2500 miles. It has been decided to place these three boats in hand, because it is necessary to make an experiment. In the estimates of 1907 provision is not made for constructing other boats of these types, it being intended to await the result of the trials.—*Army and Navy Gazette.*

THE SUBMARINES AND SUBMERSIBLES OF FRANCE. (*By a French Correspondent.*)—France was the first nation seriously to adopt the submarine for warlike purposes. In 1885 she possessed the trial vessel the *Gymnote*, which managed, even at that period, to solve a good many problems in connection with submarine navigation. This little vessel, which only had a small displacement and a very restricted radius of action, since it was entirely operated by electricity, was for several years used as a boat for trial purposes rather than for fighting. However, in 1888 the general idea was taken up upon a wider basis, and a submarine of considerably greater displacement was commenced by the naval authorities, but was not completed till 1895.

In the meantime a civil engineer, Monsieur Goubet, invented a transportable submarine, which he named after himself. It was launched in 1891, but, although considerable ingenuity had been evinced in its design and construction, its trials did not satisfy the naval authorities, who refused to accept it. The inventor, in spite of this rebuff, set about to construct another vessel on more or less the same lines, but more perfect in its action. The private trials of this second boat were apparently eminently successful, and again the invention was offered to the State. It was again refused. The authorities, however, testified to their appreciation of the inventor's apparatus, and of the following capabilities of which it was possessed: Sinking while at rest, whereas previously it had only been possible to do this readily when the vessel was in motion and by the aid of deflecting planes; motion at a predetermined depth without going off its course; motion on the surface in bad weather without being inconvenienced by the waves; and steering without a rudder, the propeller shaft being articulated, and taking the place, not only of the rudder, but of the raising and lowering planes.

Due largely to the data obtained with this boat, the naval submarines made rapid progress, and this type of boat was deemed to be necessary to the French Navy. In 1896 the French Admiralty asked for tenders for

a submarine with its accessories. The specification called for a speed of 12 knots on the surface, and a radius of 10 miles at 8 knots when submerged. The armament was to consist of two torpedo tubes. The next year numerous plans were submitted for complete submarines, as well as for accessories. The most noteworthy were, first, those of the engineer, Lauboeuf, who gave to France a new type of boat, which was to have a great future—the submersible; secondly, those of M. Romazzotti, engineer of naval constructions, for a submarine pure and simple; and lastly, the torpedo carriers of the Russian engineer, Drezwieski, which allowed of the emission of the torpedo tube and accessories.

From this time onwards France made rapid strides in submarine navigation.

In 1895 the *Gustave Zédé* could sink to a depth of 12 m. At 8 knots with 15 deg. of rudder, and without heeling more than 5 deg., it could turn in a circle of 180 m. diameter. In some of its trials it ran at a speed of 9 knots during eight hours. In the same year *Goubet II* carried out its trials. She was pointed at both ends, and her plates varied in thickness from 7 mm. to 22 mm., according to their position in the hull. They were of bronze. The motive power was electricity, and the boat carried two torpedoes.

In 1897 the *Gustave Zédé* ran into the torpedo-boat *No. 139*. The latter had only seen that it was in the course of the submarine when the boats were but a few yards apart, and too late to change its direction. The submarine hit the torpedo-boat aft and burst in a compartment, which filled so rapidly that the vessel had to be beached at once. The submarine suffered no injury. At this time the problems of immersion at will and the maintenance of motion at any desired depth had been solved. In 1898 some experiments were made which showed that the *Zédé* was invisible at a distance of a mile even when it was moving at the surface. This boat was definitely incorporated in the fleet in June, 1899.

The *Morse*, another vessel, which was also added to the fleet in 1899, developed on her trials a speed of 12.32 knots. For the greater part of her length forward she was shaped like a porpoise, but aft her form was similar to that of a Whitehead torpedo.

In 1899 a public subscription got up by the newspaper *Le Matin* enabled two submarines, *Français* and *Algerien*, to be laid down. They were of the same design as the *Morse*, and in this year also an important event was the launching of the *Narval*, a submersible built in accordance with the designs of M. Lauboeuf. This vessel externally had the aspect of a torpedo-boat of small displacement. Below water level she was similar to the *130* type. She had two shells. The interior was like that of a Whitehead torpedo, and the space between the two shells was utilized for water ballast, the water being let in or pumped out according as it was desired to sink or to remain at the surface. There were two rudders, one for vertical and one for horizontal motions. The air reservoir was placed aft. To make it certain that the boat would rise to the surface, there were external lead weights which could be detached from inside the hull. The motor for navigation on the surface, or half immersed, was a steam engine which was worked by a petrol-fired boiler. During her trials the *Narval* did 252 miles at 12 knots, and 624 miles at 8 knots, which gave her a radius of 24 and 78 hours' steaming respectively. In 1900 she actually did 13 knots. The motor for submarine work was electric, and it was fed by a battery of 158 accumulators. With this motor the vessel traveled 25 miles at 8 knots, and 70 miles at 5 knots. The accumulators were charged by means of the main steam engine driving a dynamo when the boat was

at the surface. The *Narval* was fitted with four Drezwieski apparatus for Whitehead torpedoes. The crew was composed of two officers and eight men.

This type of vessel was definitely incorporated in the active fleet in June, 1900, and from this time France possessed boats which could reach Corsica, Sicily, and Malta, as well as parts of the coast of Italy. With Oran as their home port they could get as far as Gibraltar and from Cherbourg or Dunkerque they could sail along the coasts of England.

The year 1900 saw the construction of four submarines of the *Farfadet* type, and the naval programme included a fleet of 38 vessels, counting the submersibles. In May of that year a fleet of submarines for defence purposes was stationed at Toulon for the first time, and in the same year some remarkable experiments to show the habitability of the *Morse* and the *Narval* were carried out. Both vessels remained under water for 12 hours with their full complement of men, and none of these felt any fatigue. In the same year the submersible *Sirene* was occupied for 11 hours in diving and in attack maneuvers against the northern squadron.

In 1902 three submarines and five submersibles made numerous attacks on the same squadron, which was protected by a fleet of destroyers and torpedo boats. These attacks were carried out over a line 20 miles in length. In the same year the submersible *Silure* descended to a depth of 39 meters (126 feet 3 inches) and at the maneuvers just mentioned it often sank to depths of 18 meters and 20 meters so as to pass safely under the hulls of destroyers, and to attack cruisers under the most effective conditions.

During the years 1902, 1903, and 1904, submarines and submersibles under their own machinery frequently journeyed from Cherbourg to Brest and back, in all sorts of weather and notwithstanding fog. It had been realized in 1902 that bad weather had less effect on them than on the torpedo-boats detailed to accompany them. The fuel capacity was large enough to prevent the necessity of taking any supplies at Brest, and the return voyage represented a distance of 180 miles.

Comparative trials between submarines and submersibles were made in 1904. The latter were much preferred by the crews, and showed themselves greatly superior in every respect to submarines pure and simple, except as regarded the rapidity of plunging, though the actual difference in time was not considerable. The submersibles are better sea boats in bad weather; their maneuvering qualities are much superior to those of the submarines, and are practically equal to those possessed by torpedo boats of the same tonnage.

In 1904 experiments were made with the first submarine fitted with a petrol motor for surface work in addition to the electric motor for underwater work. This submarine had a displacement of 202 tons, and was decidedly more comfortable to work in than any of the others which had preceded it, thanks to its superstructure forward. The designer was the naval constructor, M. Maugas. Comparative trials were made between this vessel and the *Aigrette* of M. Lauboeuf, in which the latter showed an undeniable superiority before a special commission appointed by the Minister of the Marine.

The year 1905 was marked by the sad accident to the *Farfadet*—an accident attributed to the negligence of its commander, who delayed too long in closing the manhole in the conning tower—or, as the French call it, the kiosk—and was surprised by the sudden descent of the submarine. As a result of carrying out the same maneuvers time after time and of living constantly face to face with danger, the work finally got to be done perfunctorily instead of, as at first, having the greatest care bestowed on it.

In this year—1905—Calais was made a submarine base port, with the object of commanding the Channel up to a certain point, and of protecting Dunkerque and the surrounding districts, while at the same time threatening the English coast.

In February, 1906, came the accident to the *Bonite*. The Toulon submarine flotilla was maneuvering against a squadron which had arrived off the port, and the *Bonite* had successfully torpedoed the armored cruiser *Condé* and the battleship *Iena* at distances of about 200 meters (218 yards), when it was decided to make an attempt to torpedo the Admiral's flagship *Suffren*. To do this it was necessary to sink to a depth of 20 meters so as to pass under some destroyers. A course was made for the flagship, and after a short interval the submersible was brought to the surface so that the course might be checked. The commander then saw in the periscope the mass of the *Suffren* right in front of him, at a distance of from 35 to 40 meters. The order to plunge was immediately given, but it was too late to avoid a collision. The shock was tremendous. The men in the submersible were violently thrown about. There was, however, no panic. The safety weights were at once cast loose, and the water ballast tanks emptied. The submersible came to the surface like a bit of cork. It was then found that the stem and the forward water ballast tanks were crushed in, and that several of her plates were torn. The boat, however, easily got back to Toulon without assistance.

The battleship had a hole .9 by .48 meters in area torn in a plate on the starboard side below the armored belt. She immediately made for Toulon, where she had to be dry-docked the next day. The pumps had to be kept going all night. This incident is quoted as showing the strength of the French submarines.

All the submarines actually in service in the French Navy are propelled entirely by electricity, and have but a limited radius of action. This is their principal fault. The radius of action of the earlier types only allows of a journey of from 30 to 40 miles from the electrical charging station. In addition to this the accumulators are subject to rapid deterioration; they require careful management, take up a lot of space, and are very heavy. All these added together limit the employment of this type of boat. On the return to Marseilles, after the naval maneuvers, following on a severe storm encountered near la Ciotat, the accumulators of the *Gustave Zédé* suddenly ran down, and the submarine could not move. It had to be towed back to Marseilles by the *Utile* to recharge its accumulators. This episode does not speak very strongly in favor of the submarine actuated entirely by electricity.

The speed is, as a rule, from 8 to 10 knots, and it is not enough to allow a submarine to reach even a slow ship, unless the latter is moored or unless the former actually finds itself in its course. If the enemy steamed at a quick rate, often changing his direction, a submarine would have the greatest difficulty in reaching him, unless the route had been guessed and the submarine stationed directly in his course.

In order to remedy the slow speed and the limited radius of action, the types most recently launched or being constructed have been considerably modified. The submarine has been made more closely to approximate to the submersible, and in the near future they will only form one class. The submarines of 320 tons displacement will be provided with petrol motors of 600 horsepower, capable of giving them a speed of 12 knots.

The submersible is in every way the best arm of submarine defence, whether used by day or by night. It is at will either a submarine or a torpedo-boat. The submersible cruises like a torpedo-boat and plunges

like a submarine at the exact moment when it is necessary to do so. It is ready for action as long as any fuel remains in its tanks. When it is moving at the surface the small target which it offers to the enemy renders it almost invulnerable; it becomes actually so by disappearing beneath the waves, though when it is steaming at the surface it is more visible than the submarine by reason of the smoke which escapes from its funnel, and which might attract an enemy's notice. If it can surprise an enemy before the latter can get up speed, it can approach him with impunity, dive beyond the radius of the automobile torpedo steer its course by the aid of the periscope, and, when the proper distance away, torpedo him.

The submersible is not tied to any particular port, like a submarine, because petrol can be obtained anywhere. It can travel long distances without having to charge accumulators and when it is under steam it is ready to plunge. Its battery of accumulators need not be very powerful, for it has, relatively, only a short distance to go under water, and its battery can be charged as the boat is traveling.

If for any reason the submersible is surprised with its accumulators discharged, it promptly sinks and waits for some time until it thinks that the enemy has got tired and gone away. Then it rises in a cautious manner, carefully sweeping the horizon with its periscope. If no enemy is visible, it rises completely to the surface, starts its motor and charges its accumulators as it steams away. The radius of action of a submersible is only limited by the capacity of its fuel tanks. The combustible is, moreover, more easily taken on board than is the case with any torpedo-boat.

The French claim that from a defensive point of view the submersibles restore—to a certain point, at any rate—the equilibrium overthrown, to their detriment, by the formidable increases in the English, German, American, and Japanese fleets.

The difference in speed between the submersible and the torpedo-boats of the same displacement and exterior form is the consequence of various causes. For example, the weight of the hull of the submersible is much greater than that of the torpedo-boat. Having, as it has, to support very high pressures, its scantlings are of heavy section. The weight of the water ballast tanks and of the air reservoirs, the safety weight, etc.—in short, of the necessary apparatus for rising or sinking, is very great. It is evident, therefore, that the weight remaining to be apportioned to the motive power is much reduced as compared with the case of the torpedo-boat; and, in addition to this, this weight has to be shared between two kinds of motive power, which take the places of one another, but do not combine their forces. One of these is for motion on the surface, the other for use beneath the sea.

In order to employ it for submarine working the steam engine must be so installed as to be capable of instantaneously getting rid of the gases of combustion or of the fuel employed. This can only be done with the aid of petrol. A short time before the chimney aperture is closed the cocks supplying the liquid to the burners must be closed, and the draft allowed to clear away the products of combustion. Then the chimney may be hermetically closed without any danger.

Although it can be said that the steam engine is much to be preferred on board a submersible to a petrol motor, with steam the consumption can be kept much better within desired limit, while with the petrol motor the consumption is the same whatever the speed is; moreover, explosions resulting from leaks render dangerous the employment of spirit in a confined space where the ventilation necessary to carry off the explosive mixture is practically unobtainable. On the latest types of submersible now under

construction, however, petrol motors of 330 horsepower are being installed. These are capable of imparting a speed of 11 knots. The 398-ton boats will each have a steam engine of 700 horsepower, which will give a speed of 12 knots, while the latest types ordered this year are to have a speed of 15 knots.

The *Bonite-Suffren* incident has suggested to some people a new set of tactics for submarines for small craft against which a torpedo could not be used—namely, an attack by shock. It is thought that with a special form of ram and a careful study of the best conditions of maneuvering to carry out, there might be a good chance of paralysing in a short time a number of destroyers, which, following their ordinary tactics, were defending the armored vessels against the submarines. On the other hand, the only method to adopt which would seem to give a chance of success to the larger vessels is to build them of high speed. Then quick preconcerted changes must be made in the order of steaming. In such event the slower submarines could only by chance get near enough to attack them.

The cruises of submersibles, and the attacks by submarines, take place so frequently now-a-days in the French Navy—at least three times per month—that no more attention is paid to them than to the other maneuvers of the fleet. However, at the close of the last naval maneuvers, Admiral Fournier, in his order of the day, thus expressed himself: "On the other hand, the operations of coast warfare which have been carried out by the fleet before Algiers, Bizerta, Toulon, and Marseilles, have shown incontestably that the chief arm of defence of ports is the torpedo in all its forms, but especially when used by torpedo-boats at night and by submarines by day. The following figures show what ravages the torpedo-boats and submarines have made in the ranks of a fleet which took part in these operations: The fleet had put out of action 5 vessels before Bizerta, 5 before Toulon, 16 before Marseilles during the morning of July 31, 25 before Marseilles during August 2, without counting those which would have been torpedoed before Algiers, where the submarines were not present during the maneuvers of July 6. It cannot, therefore, be too emphatically insisted upon that the protection of the coast of France in the future will be by a numerous fleet of torpedo-boats and submarines covering the ports and the points on the shore most accessible to attack by an enemy. Such a fleet will have even greater effect than shore batteries. At sea the arm to win must incontestably be the vessel of large displacement, but torpedo-boats and submarines can destroy a victorious fleet wishing to take advantage of its success by finally attacking the enemy's ports. From this point of view the coast operations of our fleet have profitably taught us lessons which carry us beyond the point where they were left by the English Navy in its brilliant mobilization maneuvers on the high seas last month. (Signed) Le Vice-Admiral Commandant-en-Chef l'Armée Navale, FOURNIER."

What is to be the future of the submarine? Among French naval authorities it is hoped that in the more or less near future the best defensive arm will be the "submersible destroyer." Such a vessel should have a speed of 20 knots at the surface, and at least 15 knots submerged, as well as a wide radius of action, so as to be able to make cruises of considerable duration on the enemy's coasts, or on the usual courses steered by naval squadrons and commercial fleets. Such a type would not cost much to maintain, and it would be the best protective arm for weak nations, and would enable them to guard their independence and to repulse any invasion or encroachment.

The following statistics regarding the French power in submarines and submersibles are of interest. During the last few years orders to lay down vessels were given as follows:

October, 1903—Six submarines of the *Emeraude* type, and of 390 tons.
October, 1904—Two submersibles of the *Circe* type, and of 350 tons.
August, 1905—Eighteen submersibles, 390 tons.

At the time of writing there are being constructed at the arsenals:

Cherbourg—Three submarines, *Emeraude* type, 390 tons; practically completed.

Cherbourg—Two submarines, *Guêpe* type, 45 tons; time of completion indefinite.

Cherbourg—Two submersibles of 398 tons, to be delivered in June, 1908.

Cherbourg—Ten submersibles of 398 tons, to be delivered in 1908-1909.

Five others are to be ordered. They will be of a larger type, and are to give 15 knots at their trials. They will be finished in 1909-1910.

Rochefort—Three submersibles of 398 tons, to be delivered in 1908.

Rochefort—Five others will be ordered, and will be delivered in 1909-1910.

Toulon—The submersible *Omega*, launched and being completed.

Toulon—Two submersibles of 398 tons, to be delivered in 1907.

Toulon—Ten submersibles of 15 knots speed are to be ordered for delivery in 1908 to 1910.

The *Emeraude*—first of her type—was launched some months ago. She is of sufficient size for her crew to live on board as on ordinary torpedo-boats or destroyers. Each officer has a separate cabin.

The question of laying down next year 18 submersibles of 398 tons each, and two of 800 to 900 tons of an experimental type, evolved from study of the vessels actually in service, is being seriously considered.

The following table gives the tonnage of the French submarines and submersibles at present built:

								Total tons.
1885	1	submarine	of	31	tons			31
1888	1	"		266	"			266
1897	1	"		136	"			136
1898		—				1	submersible of 116 tons	116
1899	4	"		184	"			—
"	2	"		143	"			1,022
1900		—				4	" 157 "	628
1901	20	"		68	"			—
"	1	"		168	"			—
"	1	"		223	"			—
"	1	"		202	"			1,953
1902		—				2	" 175 "	350
1903	6	"		392	"	1	" 301 "	2,653
1904	2	"		45	"	2	" 361 "	792
1905		—				15	" 398 "	5,970
1906		—				23	" 398 "	9,154
							Total	23,071

The two following tables give the names, designers, and principal particulars of the types of submarines and submersibles in the French Navy:

SUBMARINES.

Year.	Name.	Designer.	Number of Units.	Tonnage.	Length.	Breadth.	Draft.	Horse-power.	Method of propulsion.	Number of propellers.	Speed, Knots.	Number of torpedoes.	Number of officers.	Number of men.
					ft. in.	ft. in.	ft. in.							
1885	Gymnote.....	Romazotti.....	1	31	85 9	5 10	5 10	95	Electricity	1	8	2	1	8
1888	Gustave Zédé	—	1	266	160 0	10 6	10 2	720	,,	1	9	3	2	11
1897	Morse	Romazotti.....	1	186	118 1	9 0	4 8	300	,,	2	12	3	2	8
1899	Français.....	,, ...	2	143	118 1	9 2	9 0	360	,,	2	13	3	1	8
,,	Farfadet.....	Maugas.....	4	184	135 6	9 6	9 2	280	,,	1	12	4	1	8
1901	Naiade	Romazotti.....	20	68	76 1	7 6	8 8	60	,,	1	8	2	1	4
,,	X	,, ...	1	168	122 8	10 2	7 6	220	Petrol and electricity	1	8	5	1	4
,,	Y	,, ...	1	213	142 2	9 10	7 8	250	,,	2	11	4	—	—
,,	Z.....	Maugas.....	1	202	136 6	9 10	9 10	190	Petrol	2	12	4	—	—
1903	Emeraude...	,, ...	6	390	145 5	12 9	12 0	600	Petrol and electricity	2	12	6	2	19
1904	Guêpe	Petit Homme.	2	45	66 4	6 10	6 7	240	Electricity	1	10	2	1	6
,,	Goubet II	—	—	10	26 3	8 8	—	—	—	2	—	2	—	—

SUBMERSIBLES.

1898	Narval	Lauboeuf.....	1	116	111 7	12 3	5 2	250	Steam and electricity	1	13	4	2	8
1900	Sirene	,, ...	4	157	110 6	11 3	5 2	217	,,	1	12	4	2	8
1902	Aigrette	,, ...	2	175	117 8	12 9	8 3	200	Petrol and electricity	2	11	4	2	9
1903	Omega.....	Bertin	1	301	160 5	13 8	9 0	380	Petrol	1	11	4	2	17
1904	Circe	Lauboeuf.....	2	351	164 6	16 0	10 2	440	Steam and electricity	2	11	7	2	20
1905	Q 51 to 66	,, ...	15	398	167 8	16 2	10 3	700	,,	2	12	7	2	22
1906	Q 67 to 69	,, ...	3	398	167 8	16 2	10 3	700	,,	2	12	7	2	22
,,	Q 70 to 89	—	20	—	Details	still	unknown	—	—	—	15	—	—	—

The *Aigrette* and her type are considered the best submersibles now in service. In spite of their only having a displacement of 175 tons, their fuel capacity enables them to run twice from Cherbourg to Portsmouth and back without bunkering, and so they are able to make a cruise along the English coast. The *Cigogne*, the second of this type, is fitted with a Diesel motor. Her full speed afloat is 12 knots, and she has 5000 liters of paraffin in her bunkers, so that she can run for 70 hours at a fair speed. The Diesel motor, however, has not proved itself wholly suitable for the purpose.—*Engineer.*

GERMANY.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Pommern	13,200	Stettin.	Launched Dec. 2, 1905.
Hannover	13,200	Danzig (Schichau Works).	" Sept. 26, 1905.
Schleswig-Holstein	13,200	Kiel.	" Dec. 17, 1906.
Schlesien	13,200	Danzig.	" May 28, 1906.
Ersatz Bayern	19,000	Wilhelmshaven.	Building.
" Sachsen	19,000	Bremen.	"
" Baden	19,000	—	Authorized.
" Würtemberg	19,000	—	"
Armored Cruisers.			
Gneisenau	11,600	Bremen.	Launched June 14, 1906.
Scharnhorst	11,600	Hamburg.	" March 22, 1906.
E	15,000	Kiel.	Building.
F	15,000	—	Authorized.
Protected Cruisers.			
Danzig	3,200	Danzig.	Launched Sept. 23, 1905.
Koenigsberg	3,200	Kiel.	" Dec. 1905.
Stuttgart	3,420	Danzig.	" Sept. 22, 1906.
Stettin	3,420	Stettin.	Launched March 7, 1907.
Nürnberg	3,420	Kiel.	Launched Aug. 28, 1906.
Ersatz Pfeil	3,520	Danzig.	Building.
" Komet	3,500	Hamburg.	"
——	3,500	—	Authorized.
——	3,500	—	"

THE LAST OF THE DEUTSCHLAND CLASS.—The German battleship *Schleswig-Holstein* was launched on December 17 at Krupp's Germania shipyard, Kiel, Germany. The following are the principal dimensions: Length between perpendiculars, 121.5 meters (398 feet 7 inches); greatest breadth, 22.2 meters (72 feet 10 inches); draft, 7.62 meters (25 feet).

Her belt armor has a thickness of 240 millimeters (9 7/16 inches) amidships, tapering down to 100 millimeters (3 15/16 inches) at both ends. The armored deck extends from stem to stern, and is curved down at the sides to the lower edge of the belt armor. The ship is fitted with an armored citadel and an armored gun-deck casemate. There are also two armored conning towers, the plates of which are 300 and 140 millimeters (11 13/16 inches and 5½ inches) thick. The armament consists of four 28-centimeter (11-inch) guns protected by turret armor 280 millimeters (11 inches) thick; ten 17-centimeter (6 11/16-inch) guns protected by the casemate armor; four 17-centimeter (6 11/16-inch) guns in separate casemates; twenty 8.8-centimeter (3 7/16-inch) guns; four 3.7-centimeter (1 7/16-inch) quick-firing guns in the fighting tops; four 8-millimeter (5/16-inch) machine guns; six under-water torpedo-launching tubes.

There are three triple-expansion main engines of 16,000 indicated horsepower, supplied with steam by 12 multitubular Schulz boilers, and designed to give the ship a speed of 18 knots. The normal coal capacity is 700 tons; this can be increased to 1600 tons by filling the reserve coal bunkers. The double-bottom compartments will contain 200 tons of coal-tar oil, which can be used for firing the boilers.

The tonnage of the *Schleswig-Holstein* is 13,200, and there are four other ships in the same class—the *Deutschland*, the *Hanover*, the *Pommern*, and the *Schlesien*. The complement for these ships is 729 officers and men.—*Nautical Gazette.*

BUILDING PROGRAM.—The program of construction for 1907-1908 contemplates the laying down of two 19,000-ton battleships (*Ersatz Baden* and *Ersatz Würtemberg*), one 15,000-ton armored cruiser (*F*), two 3500-ton cruisers, and twelve torpedo-boats, of a total cost of 163,712,500 francs. The new battleships are to be similar to the *Ersatz Bayern* and *Ersatz Sachsen*, already begun, having main batteries of fourteen 11-inch guns in seven turrets of which three are on the middle line. The new armored cruiser is like *E*, building at Kiel, except that she is to have turbine machinery. It is said the main battery of these ships consists of ten 11-inch guns. The two small cruisers are sister ships to the *Ersatz Pfeil* and *Ersatz Komet* and are slightly bigger than the *Ersatz Wacht, Nürnberg*, and *Stuttgart*. The torpedo-boats are of 525 tons displacement and to be armed with four 3.5-inch guns.

The first German submarine, now under trial at Kiel, is designated U_1. She is of 240 tons displacement when submerged, 200 tons when on the surface, 39.9 meters length, 3.10 meters beam, 2.50 meters draft, surface speed 11 knots, submerged speed, 9 knots, armament one 18-inch torpedo tube and three torpedoes.—*Le Yacht.*

GREAT BRITAIN.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Bellerophon	18,400	Portsmouth.	Building.
Téméraire	18,400	Devonport.	"
Superb	18,400	Newcastle.	"
Lord Nelson	16,500	Jarrow (Palmer).	Launched Sept. 4, 1906.
Agamemnon	16,500	Glasgow (Beardmore).	" June 23, 1906.
Africa	16,350	Chatham.	Under trial.
Britannia	16,350	Portsmouth.	" "
Armored Cruisers.			
Minotaur	14,600	Devonport.	Launched June 6, 1906.
Shannon	14,600	Chatham.	" Sept. 20, 1906.
Defence	14,600	Pembroke.	Building.
Invincible	17,250	Newcastle.	Building.
Inflexible	17,250	Clydebank.	"
Indomitable	17,250	Glasgow.	Launched Mar. 16, 1907.

THE NEW CHANNEL FLEET.—When Lord Charles Beresford takes over the *King Edward VII* as his flagship from Sir William May the reconstituted Channel fleet will consist of fourteen battleships, eight of which are the newest, fastest, and most powerful afloat. The remaining six are constituted as three pairs, which could either be worked together as a smaller squadron for the elucidation of problems, or would be useful in many

ways as auxiliaries to the homogeneous battle fleet. Doubtless it is intended—in fact, it has been so officially announced—that as soon as possible the *Lord Nelsons* will be attached to this fleet; but looking at its constitution as at present arranged, it is well to compare it with the nearest force it may possibly be called upon to encounter. The German active fleet—which, so far as battleships are concerned, is practically the German Navy—consists of sixteen vessels, divided into two squadrons. These vessels are three ships of the *Deutchland* class of 13,200 tons, five of the *Braunschweig* class of 13,200 tons, five of the *Wittelsbach* class of 11,900 tons, and three of the *Kaiser* class of 11,130 tons. It will be noted that the heaviest and latest of these ships have not a displacement equal to that of our own *Majestic* class and, moreover, that there is nothing approaching homogeneity in these squadrons. The total displacement of the sixteen ships amounts altogether to 200,000 tons, the heaviest guns mounted in the fleet being of 11-inch caliber, of which the first eight ships carry thirty-two, the next heaviest gun being of 9.4-inch caliber, of which the second eight carry thirty-two. On the other hand, the aggregate displacement of the battleship force to be under the command of Lord Charles Beresford is 210,100 tons, the *King Edwards* alone carrying thirty-two 12-inch guns and thirty-two 9.2-inch guns, or a battery superior to that of the whole German fleet. The remaining six ships carry as their heaviest armament sixteen 12-inch and eight 10-inch, or just sufficient to give the commander-in-chief a little bit in hand. Again, if we look at the matter of speed—and the speed of the slowest ship is the speed of the squadron—the German admiral, in whatever way he may divide his force, cannot get within two knots of the speed of the *King Edwards*, and, of course, no one who is not a fool, would credit Lord Charles with wilfully reducing his speed by tying slower ships to the *King Edwards*. The net result, then, of these reflections is that so far as any possible danger from the Baltic is concerned, the Channel fleet alone will be sufficient to meet it, and yet the Channel fleet will be supported by the Home fleet, and, as we showed in November last, this force with any possible composition must in itself be equal in fighting force to the German active fleet; but we must wait until we actually know what the composition of the Home fleet is to deal adequately with this matter.—*Army and Navy Gazette.*

The *Indomitable*, the first of the new class of armored cruisers of which the *Inflexible* and the *Invincible* are also nearing completion, and which compare with the old armored cruisers like the *Dreadnought* does with the older battleships, was successfully launched in the Clyde on March 16. She is of 17,250 tons, is 530 feet long, exceeding the older armored cruisers by 50 feet, has turbine engines, and is expected to attain the high speed of 25 knots an hour. The armament of the *Indomitable* includes eight 12-inch guns almost equaling the main battery of the *Dreadnought*. The two sister ships will be launched within a fortnight.—*New York Times.*

The *Bellerophon*, *Téméraire*, and *Superb*—in hand at Portsmouth, Devonport, and Elswick, respectively—will, it is said, differ very considerably from the *Dreadnought* in appearance, nor will they be sisters to that ship, except in general details.—*Engineer.*

The *Glasgow Herald* says the contract for the battleship of the *Dreadnought* type to be built by a private yard has been placed with Armstrong, Whitworth & Co., Newcastle, and the contract for the machinery with the Wallsend Slipway Company. The engines for the two sister ships building in the dockyards are to be manufactured by the Fairfield Company, Glasgow, and Hawthorn, Leslie & Co., Newcastle. Two years are specified for the delivery of the engines, there being a penalty of £100 daily for any delay beyond that period. The new battleships will have a displacement of 18,400 tons, or more than the first *Dreadnought*, whilst the gun power will also be greater. The vessels will have a speed of 21 knots.

The new coastal destroyers *Glow-worm*, *Gnat*, *Grasshopper*, and *Greenfly*, building at Chiswick, are in future to be respectively known as *Nos. 7, 8, 9,* and *10* first-class torpedo-boats, and are to be attached to the Sheerness-Chatham flotilla on delivery from the contractors.

The *Warrior*, the last of the cruisers of the *Duke of Edinburgh* class to be completed, has carried out her official trials satisfactorily. The engines, on her eight hours' full-power trial, developed a horse-power of 23,641, and like her three sisters, the *Achilles*, *Cochrane*, and *Natal*, she exceeded the designed speed on her trials by over one knot which is very satisfactory indeed.—*Army and Navy Gazette.*

The *River* class of destroyers are to be re-armed; the five 6-pounder quick-firing guns are to be displaced in favor of three 12-pounder 8-hundredweight quick-firing guns which will be taken from other ships.—*Army and Navy Gazette.*

ST AMOUNT FOR NAVY ESTIMATES FOR THE COMING AND FIVE PREVIOUS YEA

	Year.					
	1902-1903	1903-1904	1904-1905	1905-1906	1906-1907	1907-1908
EFFECTIVE SERVICES.	£	£	£	£	£	£
Wages of officers, seamen, and boys, coast-guard, and Royal Marines	5,962,000	6,312,800	6,691,000	6,672,000	6,810,700	6,869,700
Victualling and clothing for the Navy	2,023,500	2,292,500	2,428,000	2,256,600	2,053,200	1,996,400
Medical establishments and services	246,500	259,000	293,000	277,500	275,500	268,700
Martial Law	17,700	15,600	15,500	14,000	14,700	14,200
Educational services	101,700	116,100	154,000	161,900	165,600	172,500
Scientific services	65,000	69,400	72,600	69,300	65,100	65,100
Royal Naval Reserves	286,900	297,500	404,500	420,600	426,600	418,300
Shipbuilding, repairs, and maintenance:—						
Section I.—Personnel	2,661,500	2,991,800	3,044,200	2,768,300	2,407,600	2,549,900
" II.—Matériel	4,812,700	4,786,700	5,062,800	4,816,900	2,827,200	3,085,200
" III.—Contract work	7,665,800	9,571,500	10,314,000	7,827,800	8,588,400	7,646,000
Naval armaments	3,356,400	3,206,100	3,646,000	2,986,000	2,986,000	2,348,700
Docks, buildings, and repairs at home and abroad	1,100,000	1,502,000	1,634,200	1,905,200	1,954,500	2,758,400
Miscellaneous effective services	368,000	402,500	444,000	454,000	482,200	401,000
Admiralty Office	294,300	306,400	327,400	396,400	351,500	364,600
Total effective services	28,962,600	32,136,800	34,531,200	30,966,500	29,408,800	28,908,700
NON-EFFECTIVE SERVICES.						
Half-pay, reserve, and retired pay	782,100	784,300	796,200	800,900	820,700	837,900
Naval and marine pensions, &c.	1,160,700	1,186,300	1,208,800	1,233,900	1,256,300	1,302,000
Civil pensions and gratuities	350,100	350,100	353,300	388,200	383,700	370,900
Total non-effective services	2,292,900	2,320,700	2,358,300	2,423,000	2,460,700	2,510,800
Grand total	31,255,500	34,457,500	36,889,500	33,389,500	31,869,500	31,419,500

—*Engineering.*

BRITISH NAVAL MANEUVERS.—It has been announced that the British Navy is in February to carry on maneuvers off the Portuguese coast with a fleet comprising 30 first-class battleships, 16 armored cruisers, and 14 protected cruisers, the aggregate displacement of these 60 vessels being 681,725 tons. This is by far the largest fleet ever assembled for any purpose whatever, and has been made up without drawing upon the reserve squadrons. It exceeds the present combined battleship strength of France and Germany.

Of the 30 battleships, seven are of over 16,000 tons each, and only six are under 14,000 tons. All but three of the armored cruisers displace more than 10,000 tons each. The average displacement of the battleships is 14,645 tons, of the armored cruisers, 11,626 tons; of the protected cruisers, 4025 tons; of the entire fleet, 11,362 tons.

The value of such maneuvers is very great inasmuch as they form the only available means whereby officers and men can become familiar with the handling under war conditions of the great forces entrusted to their care. Strictly bellicose regulations are maintained in all cases, and the discipline is as strict as if war were actually a fact. Vigilance, ingenuity, and activity are at a premium, every man connected with the operations being kept on the alert; and the results, as determined by the verdicts of competent judges upon the fleets, go far to make up the science of naval strategy.—*Marine Engineering.*

THE HEALTH OF THE NAVY.—The statistical report on the health of the navy for 1905, which has just been issued in the form of a Blue Book, states that the returns for the total force may be considered as very satisfactory. As compared with the averages of the last eight years, there are decreases in the ratios of cases, invalidings, and deaths, and this year's case and death ratios are the lowest recorded since 1856. The ratio of cases per 1000 of force shows a reduction of 119.29, as compared with the last eight years' ratio. The invaliding ratio, viz., 23.89 per 1000, shows a decrease of 4.98, in comparison with the average for the last eight years. As regards the death rate the ratio per 1000 was 3.9, showing a decrease of 1.42 when compared with the last eight years' ratio. The Mediterranean Station shows the highest invaliding ratio, the East Indies the highest death rate.

The average number of men sick daily was 3365.53, giving a ratio of 30.31 per 1000, and showing a decrease of 5.44 in comparison with the last eight years' average. The total days sickness on board ship and in hospital was 1,228,419, which represents an average loss of service from disease and injury of 11.06 days for each person, which is a decrease of 1.99 in comparison with the average of the last eight years. The total number of persons invalided was 2653, which is in the ratio of 23.89 per 1000, and shows a decrease of 4.98 in comparison with the average of the last eight years. Of the above total 1719 persons were finally invalided from the service. Including the marines invalided at headquarters the total number invalided out of the service was 1941.

Deaths numbered 433, a ratio of 3.9 per 1000, showing a decrease of 1.42 per 1000, as compared with the ratio for the last eight years. In the total force the average number of entries on the sick list for disease and injury per man was .73, a decrease of .02 in comparison with 1904. The average ratio of sickness per 1000 daily was 30.31, which is a decrease of 1.04, as compared with 1904. The Channel fleet shows the lowest sick rate. The total number of persons invalided was 2653, of whom 2445 were invalided for disease and 208 for injury. The death rate due to disease alone was 2.74, and that due to injuries was 1.15 per 1000.

Appended to the report there are some interesting remarks and valuable hints by Staff Surgeon Arthur Gaskell, F. R. C. S., who contributes a paper on physical culture and Swedish drill. The contribution is a criticism of the methods now practiced in the navy, and while the writer is satisfied that the present training is "quite the best the service has ever had," he has some novel proposals to offer, as follows:

"I would suggest that a British system of physical training might well be devised that would outstrip all others, and a good scheme on which to work would be the analysis by kinematograms of the movements of the champions in each line of useful physical exercise, *e. g.*, Shrubb for fast long-distance running, a Japanese rickshaw coolie or one of the Italian

Bersaglieri for long endurance in running, etc., so that a set of exercises could be elaborated to make a man useful in any particular avocation or recreation. Thus could we train muscular sense and co-ordination, and make of our sailors good shots, good marchers, good fencers, and still more justify their title as 'handy men.'"—*United Service Gazette.*

GUNLAYER TEST.—In publishing the result of test of gunlayers in H. M. fleet for 1906, the naval lords note with extreme satisfaction the very marked improvement in the results as compared with former years, including even those of 1905, when the shooting showed so great an advance over previous results. They further note that this improvement is due to a higher standard generally throughout the fleet. The following results are tabulated:

Order of Merit.	Fleet or Squadron.	No. of Ships.	No. of men Firing.	Points per Man.	First Ship in Fleet.	Scores.
1	Second Cruiser.....	6	86	98.741	*Drake*	124.49
2	Mediterranean	11	137	93.539	*Formidable*	118.31
3	Third Cruiser	5	60	90.890	*Carnarvon*	114.15
4	Atlantic	11	156	88.557	*King Edward VII*	123.09
5	First Cruiser	6	68	86.648	*Hampshire*	107.52
6	China	6	84	82.228	*King Alfred*	102.27
7	Channel	21	288	72.266	*Exmouth*	109.03
8	Tenders, etc.....	4	12	71.096	*Shearwater*	104.65
9	Cape of Good Hope..	4	39	64.441	*Crescent*	88.13
10	N. A. and W. I.....	2	16	62.019	*Indefatigable*	66.06
11	Australia	9	90	58.507	*Prometheus*	84.53
12	East Indies	4	37	56.728	*Fox*	79.02
	Total	89	1,073	80.065		
	Total, 1905 100		1,096	68.26		

Further details are supplied by the following abstract:

	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.
Number of ships that fired.....	109	139	136	121	127	139	134	108	100	89
Number of Guns....	846	1010	1121	1031	1137	1241	1296	1171	1096	1073
Number of hits	2052	2227	2831	2732	3562	4789	5096	5748	4874	5733
Number of misses..	4389	5436	6249	5709	6244	6863	7028	7664	3357	2328
Excess of hits over misses.....	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	1017	3405
Excess of misses over hits.....	2337	2909	3418	2977	2682	2074	1932	1916	Nil	Nil
Percentage of hits to rounds fired....	31.86	31.63	31.1	32.3	36.3	41.1	46.04	42.86	58.58	71.12
Hits per gun per minute:										
12" and 10" VI and VII.....	.09	.23	.29	.30	.33	.38	.53	.47	.78	.81
9.2"	.17	.32	.23	.23	.31	.35	.70	.73	1.40	2.84
6" Q.F. and B.L.	.80	1.11	1.05	1.51	1.81	2.41	2.63	2.63	4.14	5.08
47" and 4 Q. F.	1.83	1.68	1.82	1.60	1.93	2.02	2.47	2.28	3.73	4.96
Number of ships from whom no returns were received.	20	33	32	39	47	19	30	43	Nil	Nil

The companion statement for the anti-torpedo armament of the same men-of-war is issued in the form of a Blue Book. Though the Admiralty, in a prefatory minute, express their great satisfaction at the "very marked improvement" which has occurred compared with the results obtained in 1905, the return shows such a wide variation between the best and the worst results as to indicate that there is considerable room for further progress. The fact, however, that the general average is very much higher than it was in the preceding year reveals that officers and men are on the right road. The following table shows results in 1905 and in 1906:

	1905.	1906.
Number of ships that fired	86	89
Number of guns	1,118	1,421
Number of hits	2,228	4,666
Number of misses	8,291	8,845
Percentage of hits to rounds fired	21.63	34.53
Hits per gun per minute—		
12-pounders	2.12	3.417
6- and 3-pounders (except Vickers)	1.97	3.358
3-pounders (Vickers)	....	8.144

—*Page's Weekly.*

SUPERHEATER TRIALS ON A BATTLESHIP.—The battleship *Britannia* is the first warship to be fitted with steam superheaters, and the analysis of the results of her trials is interesting, as it reflects light on the economy of the system. Six of the boilers in the *Britannia* had superheaters in the uptake, and as this number was equal to drive the engines at one-fifth of their power, it was decided to run two trials, each of thirty hours' duration, the one with ordinary steam and the other with the steam superheated to the extent of 90 degrees F. The result was to reduce the coal consumption by about 15 per cent, and to reduce also the temperature of the gases escaping from the funnel by 50 degrees. In other words, with ordinary steam the coal consumption was 2.07 pounds per horsepower per hour, as compared with 1.77 pound, while using superheated steam. Again, on the higher power trials the influence of the superheating of part of the steam had its effect as on the trial at 70 per cent of the power the coal consumption was 1.5 pound per I. H. P. per hour and at full power 1.83 pound. It is, however, at low powers that the gain is most wanted, as then the consumption is high owing to the auxiliary machinery taking such a large portion of the steam. Moreover, warships run for the greater part of their time at low power, so that if the gain of 15 per cent shown on trial can be maintained in service, the coal bill for the year will be appreciably lessened.—*Scientific American.*

WARSHIP CONSTRUCTION IN 1906.—A fairly satisfactory number of new ships for the navy have this year been floated; three battleships, two armored cruisers, and a considerable number of torpedo and submarine craft have been launched, the total tonnage of the 21 ships being 85,680 tons displacement, which is considerably below the average of the six preceding years—117,700 tons. This comparison, however, scarcely represents the relative fighting efficiency of the ships, as this year represents the transitional stage in respect of design, and the fighting efficiency per unit of displacement has been enormously increased. This is, perhaps, best reflected by the fact that whereas six years ago the average price of warships was £70 per ton of displacement, it is now £100 per ton. A greater area is protected by armor of considerably higher resisting power per unit of thickness, and consequently more costly of production, so that the whole of the fighting will be done within effectively-protected quarters, rendering the enemy's light rapid-firing guns up to 6 inches bore inefficient. But an influence affecting the total cost still more is that all the primary guns are of

the highest power. The cost of a pair of 12-inch guns, with their barbette mountings, is over £100,000; the placing of ten such weapons in a battleship, instead of four, as formerly, and of eight in cruisers instead of a number of light weapons on central pivot-mountings of a relatively low cost, accounts for a large part of the difference in price. In other words, the hull and the machinery of present-day battleships represent only about 45 per cent of the total cost, as compared with something approaching 60 per cent formerly, and this, too, notwithstanding the great increase in speed. Thus, while the tonnage output of warships for the year is only equal to 73 per cent of the average for the previous six years, the cost of the ships launched this year in their completed state—about £8,500,000—is equal to 92 per cent of the cost of the ships launched in each of the past six years.

There has been a steady decrease over a period of years in the tonnage launched from the royal dockyards. Sheerness now drops completely from the list, as it is entirely confined to repair work. This promises also to apply to Chatham, and Pembroke also, after next year, may have little or no new work given to it. Portsmouth and Devonport, however, will

TABLE II.—SEVENTEEN YEARS' PRODUCTION OF BRITISH NAVY SHIPS.

Year.	Dockyard.		Private Yard.		Total.	
	No.	Tons.	No.	Tons.	No.	Tons.
1890	8	22,520	13	42,475	21	64,995
1891	8	68,100	10	39,150	18	107,250
1892	9	50,450	13	90,750	22	141,200
1893	9	32,400	5	1,919	14	34,319
1894	8	26,700	19	4,825	27	31,525
1895	8	70,350	28	66,412	36	136,762
1896	9	70,970	26	36,515	35	107,485
1897	4	31,885	22	34,111	26	65,996
1898	8	70,955	22	70,033	30	140,988
1899	6	66,900	12	53,222	18	120,122
1900	4	5,230	17	30,374	21	35,604
1901	8	64,910	24	144,190	32	209,100
1902	5	51,560	10	40,494	15	92,054
1903	4	28,290	31	120,456	35	148,746
1904	4	57,100	31	67,532	35	124,652
1905	3	46,250	19	49,950	22	96,200
1906	3	47,100	18	38,580	21	85,680
Totals	108	811,670	320	931,008	428	1,742,678

still be utilized partly for new construction; the aim is to have at these establishments one berth always occupied with a new ship. The magnificent achievement in the completion of the *Dreadnought* within 18 months of the first issue of drawings to the constructive department proclaims the satisfactory character of the organization and equipment, and does credit to the director of dockyards, Mr. J. B. Marshall, C. B., and the whole constructive department at Portsmouth, under Mr. T. Mitchell, C. V. O., the manager. Chatham and Devonport each added an armored cruiser to the fleet so that the output of the three dockyards is three vessels, of 47,100 tons. In all cases the machinery has been constructed by contract. The work remaining includes two ships of the *Dreadnought* class—the *Bellerophon* at Portsmouth and the *Téméraire* at Devonport; while at Pembroke there is almost ready for launching the armored cruiser *Defence*, and in a few months there will be laid down there a fast "mother" boat for destroyers, while at Chatham two submarine boats of the latest type, designed by Messrs. Vickers Sons & Maxim, Limited, are to be built.

Table II shows the production in royal and private yards for the past 17 years. Table III shows the production from each of the royal yards.

TABLE III.—THE PRODUCTION FROM EACH ROYAL YARD.

Yard.	1906.		1905.		Total for 17 Years.	Average for 17 Years.
	No.	Tons.	No.	Tons.	Tons.	Tons.
Portsmouth	1	17,900	—	—	224,031	13,178
Chatham	1	14,600	1	16,350	222,162	13,070
Devonport	1	14,600	1	16,350	179,718	10,571
Pembroke	—	—	1	13,550	155,020	9,120

The three battleships included in the list are the *Dreadnought*, the *Agamemnon*, built by Messrs. William Beardmore & Co., Limited, of Dalmuir, and the *Lord Nelson*, launched by Palmer's Shipbuilding & Iron Co., Limited. These three ships have been described in *Engineering*, and comparison has been drawn between them and the *Dreadnought* class; they represent the intermediate stage between previous ships and the all-one-caliber gun ship. Some critics have expressed a preference for the *Lord Nelson* class in respect that they have four 12-inch and ten 9.2-inch guns, as compared with the ten 12-inch guns for the *Dreadnought*, contending that the greater number and higher rapidity of fire of the lighter weapons partly compensates for their smaller shot and less striking energy. This, however, experience has proved is not so; the 9.2-inch gun determines the range of combat, and, moreover, the similarity in size of the 12-inch and 9.2-inch projectiles, and their corresponding action in flight, creates difficulties in range-finding, which, again, influences not only the accuracy, but the rapidity of fire in the first and most important moments of an engagement. Moreover, another influence affecting the control of fire is the increased "interference" with the larger number of guns, as compared with the smaller number of large-caliber guns. It is contended that, with unification of caliber, there is possible almost as great a rapidity of fire, with more centralized control and range-finding, and a minimum interference.

The cruisers which have been launched are the *Shannon* and the *Minotaur*, built respectively at Chatham and Devonport, and fitted with reciprocating engines by Messrs. Humphrys, Tennant & Co., Limited, and Messrs. Harland & Wolff, respectively. A sister-ship to these—the *Defence*, already referred to as nearing the launching stage at Pembroke—has had her engines from the Scotts' Shipbuilding & Engineering Co. It remains to be seen whether these vessels will be the last of the British warships to be fitted with reciprocating engines. This is likely to be the case, according to present anticipations, the *Dreadnought* having given very favorable results, as will presently be shown. The cruisers, like the *Lord Nelson* battleships, were designed by Sir Philip Watts, K.C.B., and mark the intermediate stage to the all-one-caliber gun ship; but in view of his work at Elswick, it is possible that the intermediate stage might have been dispensed with, but for the inherent and probably inevitable conservatism of government departments. Certain it is that Sir Philip Watts, long years ago, urged upon the Japanese authorities the adoption of uniformity of large-caliber guns in great numbers. The new cruisers have four 9.2-inch and ten 7.5-inch guns, and therefore are a long way behind the *Invincible* class, with their eight 12-inch guns and turbine machinery to give a speed of 25 knots against 23 knots. The cost, however, has gone up from £1,400,000 to £1,735,000, of which about half a million is due to guns and their mountings.

Amongst the smaller craft there are included eight of the new coastal destroyers, or, as they are now to be called, first-class torpedo-boats. These are specially interesting because they have express boilers fired with

oil-fuel, turbine machinery, and are of moderate size and draft, yet have a speed of 26 knots. Recently we discussed the general design.

A great advance has been made this year in connection with the propelling engines of submarine craft, and with the application of methods of obviating those unfortunate mishaps which marked the earlier stages of this new and effective weapon of warfare; but great secrecy has been very properly maintained in respect of this craft, and we content ourselves here by strongly advocating an increase in the number of vessels to be built. Nearly all the continental powers have recognized the great potentiality of the submersible boat, which is dealt with in our leading article this week. When it is remembered that for the price of one "capital" ship it is possible to build a fleet of 40 or 50 submarine boats, there should be no stint in augmenting our available fleet of these craft. It was right that we should proceed slowly in the earlier stages in adding to the navy vessels more or less experimental; but the success achieved in research work has, we understand, resulted in reliable efficiency, as well as high speed, and, consequently, we hope that next year there will be a large increase in the number of vessels to be built. One or two figures are officially available as to the increase in size of these vessels. The earlier boats were 99 feet long and 12 feet 8 inches in breadth, with a displacement of 204 tons. The later vessels, designed by the Vickers Company, are 135 feet long and 13 feet 6 inches in breadth, having a displacement of 313 tons. This has resulted in more than doubling the radius of action of the vessels, and has also given a material increase to the speed on the surface, which is to be from 15 to 16 knots. The boats to be laid down are still larger.

Another of the small craft to which passing reference may be made as suggestive of the future, is a torpedo-boat built by Messrs. Yarrow & Co., and propelled by a petrol-engine; but it is problematic whether this fuel, with its low flash-point, can be adopted for war service. Greater interest is being taken, perhaps, in tests shortly to be made with producer-gas motors; and in this connection it is worth mentioning that the oil-engine used on the *Dreadnought* for driving dynamos gave on trial 1 brake horsepower per ½ pound of petroleum. But nothing definite can be said until further trials are made as to the advantages, or otherwise, of applying the respective systems of fuel for internal-combustion motors.

Before passing to details as to the steam trials, a reference may be made to the foreign warship work during the year. Six vessels have been constructed here for navies other than the British, and the tonnage of these is 22,360, with machinery of 69,900 tons. The value of those, when completed, makes up a total of £2,120,000, which is considerably greater than in any previous year this century, with the exception only of 1905, when the total was considerably swelled by the inclusion of the two Japanese battleships, the *Katori* and *Kashima*. In the closing year the principal vessels built were the Russian cruiser *Rurik*, the two *Peruvian* high-speed cruisers *Almirante Grau* and *Coronel Bolognesi*, all three ships of interesting design, constructed by Messrs. Vickers Sons & Maxim, Limited. Messrs. Yarrow built for the Greek Navy two torpedo-boat destroyers, the *Thyella* and the *Nafkratussa*, each of 270 tons, with machinery of 7300 indicated horsepower, which gave a speed of 31.8 knots when the boats were carrying a load of 60 tons. Palmer's Shipbuilding & Iron Company constructed also a destroyer of 420 tons, with Parsons turbines to give 7200 horsepower.

Fewer new warships than usual have been subjected to steam trials this year; but there has been no falling off in the measure of success attending the tests. The results are set out in Table IV, and a comparison of the power and speed of three battleships *Britannia*, *Africa*, and *Hibernia*, belonging to the *King Edward* class, is interesting, as reflecting upon the propeller problem. Each had screws of different dimensions, and the ratio of blade to disc area was dissimilar. Without data on this question it is not possible to offer intelligent observation, and the naval authorities are

probably well advised in reserving to themselves the advantage which possession of such data confers. Generally it may be said that the results have proved that a higher proportion of blade to disc areas than formerly adopted gives better efficiency; but the whole question, especially with the increased speed of rotation, consequent on the adoption of the turbines, is beset with uncertainties. In the interests of science it would thus be of the greatest benefit if a series of definite tests were made, not alone with models, but with vessels so arranged that the influence of variants could be eliminated and each factor given its true value. In the case of the five cruisers of the *Duke of Edinburgh* class the measured-mile speeds for practically the same power have ranged between 22.84 knots and 23.65 knots—a difference which, at this high rate, shows a wide difference in propulsive efficiency, which ought not to exist with machinery made to the

TABLE IV.—STEAM TRIALS OF

NAME OF VESSEL.	TYPE OF SHIP.	BUILDERS OF SHIP.	MAKERS OF MACHINERY.	Displacement.	Type of Boilers.	Heating Surface.	Grate Area.
				tons		sq. ft.	sq. ft.
Dreadnought	Battleship	Portsmouth Dockyard	Vickers Sons & Maxim, Limited	17,900	Babcock & Wilcox	64,400	1[illegible]
Britannia....	Ditto	Portsmouth Yard	Humphrys, Tennant & Co.	16,350	Babcock & Wilcox and cylindrical	63,257	1[illegible]
Africa	Ditto	Chatham Yard	J. Brown & Co.	16,350	Ditto	63,[illegible]	1[illegible]
Hibernia.....	Ditto	Devonport Yard	Harland & Wolff	16,350	Ditto	63,[illegible]	1[illegible]
Natal	First-class cruiser	Vickers Sons & Maxim	Vickers Sons & Maxim, Limited	13,550	Yarrow and cylindrical	66,[illegible]	1[illegible]
Cochrane	Ditto	Fairfield Shipbuilding Company	Fairfield Engineering Company	13,550	Ditto	66,[illegible]	1[illegible]
Achilles	Ditto	Armstrong, Whitworth & Co.	Hawthorn, Leslie & Co.	13,550	Ditto	66,[illegible]	1[illegible]

same dimensions and standardized, as far as possible, and with ships whose form, midship section, and immersed area are exactly alike.

Table IV includes the general results of the *Dreadnought* trials. There is no question of the high propulsive efficiency attained in this case, and it is further remarkable that notwithstanding the smaller propellers, in comparison with those in other ships of corresponding mass, the efficiency in astern motion and maneuvering generally has been gratifying. We wrote fully regarding the significance of the main results attained at the time of the trials. The economy at low power was not so satisfactory as with reciprocating engines—the coal and water consumption, as will be seen, is higher than in the other ships included in the table; but the power in the case of the *Dreadnought* is taken at the shaft, and in the others at the cylinders, which accounts for quite 10 per cent of the difference. Probably in later ships it may be possible to arrive at an arrangement of cruising turbines in series, so as to obviate such a wide drop in steam pressure as obtained on this low-power trial—220 pounds at the boilers to 82 pounds at the turbine receiver. This is the difficulty with turbine machinery in warships, which are required to work at variable speeds. Four screws are

adopted in the *Dreadnought* to divide the propelling power between two separated engine-rooms; the power on each side must be equal, to obviate difficulties in steering; and thus the installation in each engine-room must be independent. To arrange cruising turbines, as well as the main turbines, in series in each engine-room, involves an increase in space, which is always difficult to find on board warships. This difficulty, however, must be met, so that for low powers the cruising turbine will be of such small dimensions as to obviate wire-drawing of the steam. With two cruising turbines in series the smaller could be disconnected for something above the minimum power, steam passing from the boiler to the second of the series. This is the arrangement adopted in treble-screw ships of small size. In the new battleships of this class modifications will probably be made, in addition to the reduction in boiler pressure decided upon—from

MAJESTY'S SHIPS IN 1906.

	First 30 Hours' Trial.			Second Thirty Hours' Trial.				Eight Hours' Full-Power Trial.			
	Speed.	Coal per Indicated Horse-power per Hour.	Water, all Purposes, per I.H.P. per Hour.	Indicated Horse-power.	Speed.	Coal per Indicated Horse-power per Hour.	Water, all Purposes, per I. H. P. per Hour.	Indicated Horse-Power.	Speed.	Coal per Indicated Horse-power per Hour.	Water, all Purposes, per I. H. P. per Hour.
	knots	lb.	lb.		knots	lb.	lb.		knots	lb.	lb.
	13 log	2.56	27.2†	16,930*	19.3 log	1.7	17.01	24,712*	21.25 log	1.51	15.56
	11.44 "	2.05	21	13,087	16.79 "	1.5	16.21	18,725	18.4 "	1.83	18.55
	11.3 "	2.001	—	12,800	17.5 "	1.793	—	18,698	19.1 "	1.872	—
	10.4 "	2.07	19.9	12,700	15.5 "	1.50	17.41	18,112	18.127 M.M.	1.92	19.66
	14.18 by bearings	2.03	20.1	15,937	21.109 M. M.	1.88	17.8	23,592	23.334 "	2.21	18.47
	14.3 M. M.	2.06	19.1	16,080	21.37 M. M.	2.04	16.4	23,654	23.292 "	1.99	16.4
	13.84 "	1.88	19.05	16,000	21.58 M. M.	1.85	17.87	23,068	23.5 by bearings	2.03	19.9

*Shaft horsepower. †Consumption for 10 hours. M. M. = Measured mile.

240 pounds to 170 pounds; but it is yet too soon to deal with these changes. In the trial at 16,930 horsepower the results are distinctly superior to those in the case of ships with reciprocating engines, the difference in steam pressures being less marked; it was 220 pounds at the boiler, 110 pounds at the high-pressure turbine, and about 4 pounds at the low-pressure turbine, with a vacuum of 27.7 inches. This advantage in economy was still more marked in the full-power trial, as is clearly shown in the table, the coal consumption being 1.5 pounds, against from 1.38 pounds to 2.21 pounds in the other ships, while the steam consumption showed almost a corresponding gain. On this trial the steam pressure at the boilers was 240 pounds; at the high-pressure turbine, 155 pounds; and at the low-pressure turbine, 10 pounds, with a vacuum of 27.2 inches. Before departing from the subject a word of caution is justified against the making of deductions from some elaborate tables of the *Dreadnought's* trials which have been published: one firm of high repute made recommendations in reference to the machinery for the new *Dreadnoughts*, which were impossible because based on the inaccurate figure published.

Another point of interest in the tables is the fact that the *Britannia* is

fitted with superheaters in the case of six of her boilers, and two 30-hour trials were run at one-fifth power—one with saturated steam and the other with steam superheated to the extent of 92.5 degrees F. at the boilers and 83 degrees F. at the engines. In Table IV the results are for this saturated steam trial. The results with superheated steam showed a steam consumption for the main engines of 13.63 pounds per indicated horsepower per hour, as compared with 16.93 pounds for saturated steam; and a coal consumption of 1.77 pounds per horsepower hour, against 2.05 pounds. In the trials at 70 per cent and full power the same six boilers were worked with the superheaters, which increased the mean temperature of the steam at the engines by 33 degrees and 31 degrees F., respectively, and the steam and coal consumption were in both cases favorably affected. The figures for the trials of the *Britannia* are here given separately. The trials suggest possibilities in connection with the use of superheated steam with turbines, and there is a probability that this will be applied in one of the new battleships.

Two of the coastal destroyers, or, as they are now officially termed, first-class torpedo-boats—the *Cricket*, built by Messrs. J. S. White & Co., of Cowes, and the *Gadfly*, constructed by Messrs. J. I. Thornycroft & Co., of Chiswick—have passed through their trials with satisfactory results. They are fitted with turbine machinery and "express" water-tube boilers, burning oil fuel. In each case the contract speed of 26 knots was easily maintained, and the economy was most satisfactory.—*Engineering.*

TABLE V.—H. M. S. *BRITANNIA* OFFICIAL SEA TRIALS WITH SUPERHEATED STEAM.

	One-Fifth Power.	One-Fifth Power.	70 p. c. Power.	Full Power.
Duration ..... hours	30	30	30	8
Boilers in use ..... No.	6 B. & W. C. Group	6 B. & W. B. Group	18 B. & W. 3 cyl.	18 B. & W. 3 cyl.
Indicated horsepower	3321	3410	13,087	18,725
Coal per indicated horsepower	2.05	1.77	1.50	1.68
Water per indicated horse-power { Main engines... / Auxiliaries.....	1693 / 4.1	13.63 / 4.76	— / —	— / —
Total.....	21.02	18.19	16.21	18.55
Steam in boilers.....	196.3	200	199.4	198
Superheat { Deg. F. at boilers..... / Deg. F. at engines....	.... /	92.5 / 83	72 / 33	87.5 / 31
Feed temperature deg F.	72	65.6	80	100
Water per pound of coal, actual.....	10.14	10.276	10.8	10.136
Water per square foot of heating surface, actual.....	5.5	5.17	4.5	7.37
Coal per square foot of grate.....	17.6	14.5	13.1	22.8
Uptake temperature ..... (Deg. F.)	C. 398	B. 347	B. 348 C. 377	B. 423 C. 430

ITALY.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Roma	12,625	Gov't Yard, Spezia.	Building.
Napoli.....	12,625	" " Naples.	Launched Sept. 10, 1904.
Vittorio Emanuele ..	12,625	" " Castellamare.	" October 1, 1904.
Regina Elena.....	12,625	" " Spezia.	" June 19, 1904.
Armored Cruisers.			
San Giorgio	9,800	Gov't Yard, Castellamare.	Building.
San Marco	9,800	" "	"
Pisa	9,800	Orlando.	"
Amalfi	9,800	Odero.	"

BUILDING PROGRAM.—The Italian program is to be modified. In order to reply by more powerful unities to the three 14,000-ton battleships of the Austrian program, Admiral Mirabello proposes to lay down in 1907 battleships of 16,000 tons and 22.5 knots speed with eight 12-inch and twelve or fourteen 4.7-inch guns. This will lead to the sale—probably to the Argentine Republic—of the two last armored cruisers of the 1905 program, the *Pisa* and *Amalfi*. These two ships were purchased, one from the Orlando Works and the other from the Odero works. They cost 24,200,000 and 23,500,000 francs, respectively, and one of them will be ready for her trials in October, 1907.—*Le Yacht.*

SAN GIORGIO CLASS.—The armored cruisers of the *San Giorgio* class are stated by the *Moniteur de la Flotte* to have the following characteristics: 9830 tons displacement 132 meters length, 22 meters beam, 18,000 horsepower, and 22.5 knots speed; armament, four 10-inch, eight 8-inch, sixteen 3-inch and eight 47-mm. guns.

The following new first-class battleships are to be completed as follows: *Regina Elena*, by end of 1906; *Vittorio Emanuele*, the autumn of 1907; *Napoli*, in the summer of 1907; *Roma*, towards the latter part of 1908. The delay in the completion of all these ships is due to the non-delivery of the armor, according to the contract. The *Regina Elena* and *Vittorio Emanuele* were laid down as long ago as 1901, and launched in 1904. These two ships are plated with Terni hard-steel armor, the conning-towers being of Terni-Krupp armor; the *Roma* and *Napoli* will have all their armor of Terni-Krupp steel. The *Re Umberto*, which last summer completed a thorough repair and overhaul, during her six hours' trial trip maintained a speed of 18.4 knots, which was considered very satisfactory, as the ship was launched as long ago as 1887.

The Italian Navy possesses at this moment three submarines ready for service, the *Delfino*, *Glauco*, and *Squalo*, the two last having been completed last summer and put through their trials in time to permit of their taking part in the maneuvers. Three more are being constructed—the *Nereide* (nearly finished), and the *Otario* and *Tricheco*, both in a fairly advanced stage. The increased vote for 1906 provide for the construction of seven more, but they have not yet been laid down.—*United Service Institution.*

The Italian naval authorities have decided to sell or break up a number of battleships and other vessels during the five years 1907-12. The list comprises 21 ships of various classes, including the *Duilio* (launched in 1877) and the *Andrea Doria* (launched in 1891), as well as 51 torpedo-boats. With the proceeds, which are estimated at £260,000, the government intends to make large purchases of coal for the Italian Navy.—*U. S. Gazette.*

The Italian Minister of Marine announces that the armor-plate factory at Terni has accepted a contract to provide the Italian Navy with 6000 tons of armor-plate at the same price as that at which the Midvale Steel Company of Philadelphia recently took a contract from the Italian government. This announcement shows that the contract with the American company has had the effect of forcing the Italian works to lower their prices, and the result is a saving of £16,000 to the Italian government.—*U. S. Gazette.*

ITALIAN TORPEDO DESTROYERS.—Six destroyers, known as the *Nembo* class, have been built by C. & T. T. Pattison, at Naples, on the plans of Thornycroft & Co. They are each 210 feet long, 19 feet 6 inches wide, and 7 feet 6 inches draft. The engines are of the four-cylinder, three

stage, compound Thornycroft inclined type, the cylinders being: High-pressure, 22 inches; intermediate, 29 inches; and two low-pressure cylinders, each 30 inches in diameter, the stroke being 18 inches. The contract was for 6000 indicated horsepower at a boiler pressure of 220 pounds. The armament consists of one 12-pounder and five 6-pounder quick-firing guns, and two torpedo-tubes. All these six destroyers reached a speed of 30 knots or over, and the results attained are stated by Messrs. Thornycroft to have been as good as those which they themselves have obtained in Great Britain with boats of similar design. As they were the first destroyers built in Italy, the fact reflects great credit on the execution of the design, and the ability of the Italian firm to turn out engineering work of a high class; a circumstance not without suggestiveness in other directions.

Messrs. Thornycroft also supplied the designs for four first-class torpedo-boats which have been ordered from C. & T. T. Pattison. These boats resemble those recently built at Chiswick, Eng., for the British Navy, excepting that they are fitted with twin-screws in place of single screws. The contract speed was 25 knots, and the actual speeds obtained on trial ranged between 25½ knots up to over 26½ knots; one boat, the *Pallade*, reaching 26.63 knots, or over a knot and a half faster than the contract speed of one class of British destroyers.

Later on four destroyers, known as the *Bersagliere* class, were ordered from the Ansaldo Company, of Genoa. These boats are also of Thornycroft design, and are 211 feet 6 inches long, 20 feet wide, and 7 feet 6 inches draft. It will be seen that these boats, following the almost invariable law of warship design, are somewhat larger than those first named—the *Nembo* class. The engines are of the same general design as in the earlier boat, and the low-pressure cylinders are of the same capacity; but the high-pressure cylinders are 1 inch less in diameter, and the intermediate cylinders are ½ inch less, the dimensions for the *Bersagliere's* engines being, cylinders 21 inches, 28½ inches, and 30 inches in diameter, with an 18-inch stroke. Steam is supplied by three Thornycroft boilers. The armament consists of four 3-inch guns and three torpedo-tubes. The full complement of men is 53 in the destroyers of both classes. It may be added that Messrs. Ansaldo are so satisfied with the *Bersagliere* design that they are building six destroyers of the class without orders.

The *Bersagliere* herself has undergone her final progressive trial with most satisfactory results. She steamed for about nine hours, and the speed was 29.02 knots, the contract speed being 28½ knots.—*United Service Gazette.*

JAPAN.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Satsuma	19,000	Yokosuka.	Launched Nov. 15, 1906.
Aki	19,000	Kure.	Building.
Armored Cruisers.			
Ikoma	13,000	Kure.	Launched April 9, 1906.
Tsukuba	13,000	"	Under trial.
Ibuki	13,000	Yokosuka.	Building.
Kurama	13,000	"	"
Protected Cruiser.			
Tone	4,100	Sasebo	Building.
Scouts.			
Yodo	1,350	Kobe.	Building.
Mogami	1,350	"	"

THE WORLD'S LARGEST BATTLESHIP.—The latest papers from Japan are very full of the launching of the *Satsuma*, of which we were informed by

telegraph some time ago. The Japanese are naturally very proud, not only of possessing the largest battleship afloat, but also of having built it themselves, as it not only marks the importance of their navy, but also indicates the most remarkable progress which they have made in shipbuilding. Their first attempt at warship-building was in 1875, when they launched from Yokosuka dockyard the wooden gunboat *Seiki*. Since then they have gone on steadily improving their appliances and methods, and extending their experience, until they can now boast of having built the biggest battleship in the world. By way of comparison between the *Satsuma* and the *Dreadnought*, the following figures are published:

	Dreadnought.	*Satsuma.*
Displacement	18,000 tons	19,200 tons
Length over all	490 ft.	482 ft.
Beam	82 "	83.6 "
Draft	26.5 "	27.5 "
Speed	21 knots	20.5 knots
Guns	Ten 12-inch and eighteen 76-mm.	Four 12-inch ten 10-inch and twelve 120-mm.

It is worthy of note that the principal architect of the navy is Captain Kondo, and the director of the Yokosuka dockyard is Captain Matsuo, both graduates of the Kolu-dai-gakko, or Imperial College of Engineering, of which Dr. Henry Dyer was the first principal; and this is another proof, if one were needed, of the important part which that institution has played in the making of New Japan. The *Satsuma* was built under the personal superintendence of Vice-Admiral Ito, director of the Working Department; Engineer-General Kuroke, director of the Engineering Department; and Engineering-Inspector Matsuo, director of the Shipbuilding Department. The plans were drawn by Engineer-Inspector Shirai, and the practical work was under the direction of Architect Okusuki. On Thursday afternoon, November 15, the *Satsuma* was launched from her building slip at the Yokosuka dockyard, in presence of His Majesty the Emperor. The Emperor was presented with a plan of the ship by Admiral Kammimura, which showed that her displacement was 19,200 tons, her length 482 feet, beam 83 feet 6 inches, and horsepower, 18,000. After the launch, about 5000 guests were entertained to tiffen in one of the buildings of the dockyard. Among the other courtesies of the occasion was a telegram from the First Lord of the British Admiralty to Admiral Siuto, Minister for the Navy, congratulating him, in the name of the British Navy, on the successful launch of the *Satsuma*, and saying that the event will enhance the reputation of the Japanese Navy. A telegram of thanks was despatched in reply. It will be seen that the draft of the *Satsuma* is 1 foot more than that of the *Dreadnought*, the Japanese having no necessity to adapt their vessels to passage through the Suez Canal. In many features she resembles the *Dreadnought*, which is not surprising in view that both vessels were designed on data acquired during the Russo-Japanese war. The belt armor, according to Brassey, will range from 5 inches to 9 inches in thickness, and all is being supplied from the State Works at Kure. The guns are also of Japanese manufacture, the larger being all 45 calibers in length. The 12-inch guns will be placed in pairs in barbettes, one forward and one aft, and the 10-inch guns will also be fully protected. An interesting feature of the launch was the mounting of the bilge blocks on sand boxes, in the fashion sometimes used for supporting the centering of arched bridges.

By opening small holes in the bottom of these boxes the blocks were released by the running out of the sand, and could thus be rapidly removed. The launching weight of the vessel was 8000 tons. The keel was laid on May 15, 1905, a fact which does credit to the appliances of the Yokosuka yard. The ship will be fitted with reciprocating engines, and not turbines, and will, as stated, be designed to give 18,000 indicated horsepower on trial. The comparison made in the table at the head of this note is taken from official figures, and is hardly just to the *Dreadnought* in the matter of speed, since on trial her turbines proved capable of developing 28,000 brake horsepower, and with 24,700 brake horsepower she easily developed 21¼ knots. In view of her reciprocating machinery, the *Satsuma's* extra foot of draft should prove very valuable, since, the weights being higher than with turbines, some command of the guns would otherwise have to be sacrificed.—*Engineering.*

NEW SHIPS.—It is reported that the two new battleships of this year's program are to have a displacement of 21,000 tons, with slightly increased dimensions; the turbine engines are to develop 26,500 I. H. P., to give the same speed as in the *Satsuma,* the armament also remaining the same.

It is further reported that the two new armored cruisers are to be 537 feet long, with a beam of 79 feet 6 inches, and a displacement of 18,650 tons. The turbine engines are to develop 44,000 I. H. P., giving a speed of 25 knots, while the armament will consist of four 12-inch guns, eight 10-inch guns, and ten 4.7-inch guns. All the new ships are to be fitted with the Miyabara type of water-tube boilers.

The dimensions of the new second-class protected cruiser *Tone,* under construction at the Sasebo yard, are reported to be as follows: Length, 403 feet 6 inches; beam, 48 feet; displacement, 4100 tons, with a draft of 16 feet 6 inches. The engines, which will be reciprocating, are to develop 15,000 I. H. P., giving a speed of 23 knots, steam being provided by 16 Miyabara water-tube boilers. The armament will consist of two 6-inch, ten 4.7-inch, and two 3-pounder quick-firing guns. There will be an armored deck 3-inch to 1.5-inch thick, with a 4-inch conning-tower. There are also under construction at the Mitso-Bischi yard, at Kobe, two despatch-vessels of 1350 tons displacement, to have a speed of 23 knots, one, the *Mogami,* to be fitted with Parsons' turbines, and the other, the *Yodogawa,* to have the ordinary reciprocating type.—*United Service Institution.*

The *Kurama* is to be launched on April 14, the despatch boat *Yodo* in the same month, and the *Tone* in May.—*Japan Weekly Gazette.*

THE MIKASA.—The battleship *Mikasa,* now being repaired at Sasebo, will be completed towards the end of this year. The vessel, launched in 1900, is of the old type as compared with the latest vessels. Taking opportunity of the present repairs, her characteristics will be improved upon on a large scale acting upon lessons of the late war. The auxiliary guns will be changed to four 10-inch pieces. The side guns will be increased by two 6-inch pieces. On completion the *Mikasa* may match the *Kashima* and *Katori.—Japan Weekly Gazette.*

STRENGTH OF THE OFFICER PERSONNEL.—According to the latest official Navy List, the Japanese Corps of Naval Officers consists of 7 admirals, 23 vice-admirals, 26 rear-admirals, 99 captains, 146 frigate-captains, 192 corvette-captains, 342 captain-lieutenants, 320 senior lieutenants and 268

lieutenants; in all, a strengtth of 1423. Of midshipmen and cadets there are 176. The proportion of the different grades to the whole strength is as follows: Flag-officers, 3.9 per cent; captains, 7; frigate and corvette-captains, 23.8; captain-lieutenants, 24; senior lieutenants, 22.5, and lieutenants, 18.8 per cent. The mean age of admirals is 56 years 5 months; of vice-admirals, 52 years 10 months; of rear-admirals, 50 years; and of captains, 44 years 3 months. The youngest admiral, Prince Arisugawa, is 44 years 1 month old; the oldest, Admiral Ito, is 62 years 9 months, while Admiral Togo is 58 years 2 months. Of the vice-admirals, the eldest is 57 years 11 months, and the youngest, 45 years 11 months; of the rear-admirals, the eldest is 55 years 6 months, and the youngest 45 years; of the captains, the eldest is 52 years 6 months, and the youngest 38 years 8 months.—*United Service Institution.*

The *Tsukuba* attained a speed of 20.5 pivots on her trial. Her battery consists of four 12-inch, twelve 6-inch, and twelve 5-inch guns.—*Le Yacht.*

According to official statistics the losses of the Japanese Navy during the last war only amounted to 3682 men altogether, of whom 2001 died (1890 killed and 111 died of wounds). The losses in the four great battles of the war were only 1129 men, which is explained by the fact that the Japanese had no vessel sunk. The greater proportion of the deaths was caused by vessels being accidentally sunk from striking mines. The detail of losses in the four battles is as follows: Killed, 192 men; died of wounds, 51 men; wounded, 886 men. Of the 886 wounded, 557 were cared for entirely on board and only 329 were sent into hospital.—*United Service Magazine.*

RUSSIA.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Emperor Paul I.....	16,900	St. Petersburg (Baltic Yard).	Building.
Andrei Pervozvannui.....	16,900	St. Petersburg (Galerney Island).	Launched Oct. 20, 1905.
Rustafi	12,500	Nicolaiev.	" Oct. 1906.
Ivan Zlatoust	12,500	Sevastopol.	" May 13, 1906.
Armored Cruisers.			
Admiral Makaroff.....	7,800	La Seyne.	Launched May 8, 1906.
Bayan.....	7,800	St. Petersburg.	Building.
Pallada.....	7,800	"	Launched Nov. 10, 1906.
Rurik.....	15,000	Vickers.	" Nov. 17, 1906.
Protected Cruiser.			
Kagul	6,750	Nicolaiev.	Building.
Outchakoff	6,750	Sevastopol.	"

NEW SHIPS.—The *Yacht* states that *Rurik* has the following novel features: A secondary battery of 4.7-inch guns instead of 3-inch, a multiplicity of armored stations, one forward with 8-inch armor, a second aft, and two on each beam with 5-inch armor; and armor on certain portions of the underwater pull. The *Pallada, Bayan,* and *Admiral Makaroff* are like the old *Bayan,* now the Japanese *Aso,* of 7850 tons, and 21 knots speed, and carrying two 8-inch, eight 6-inch, and twenty 3-inch guns.

UNITED STATES.

VESSELS BUILDING.

No.	Name.	Speed. Knots.	Where Building.	% of Completion Mar. 1, 1905.
	Battleships.			
14	Nebraska	19	Moran Bros. Co.	99
21	Kansas	18	New York S. B. Co.	98
23	Mississippi	17	Wm. Cramp & Sons.	76.3
24	Idaho	17	Wm. Cramp & Sons.	69.8
25	New Hampshire	18	New York Shipbl'g Co.	63.5
26	South Carolina	18.5	Wm. Cramp & Sons.	7.7
27	Michigan	18.5	New York Shipbl'g Co.	8.3
	Armored Cruisers.			
6	California	22	Union Iron Works.	98.8
9	South Dakota	22	Union Iron Works.	96.9
12	North Carolina	22	Newport News.	73.3
13	Montana	22	Newport News.	68.3
	Scout Cruisers.			
	Chester		Bath Iron Works.	67.7
	Birmingham		Fore River Shipbl'g Co.	64.1
	Salem		Fore River Shipb'g Co.	64.2

THE PROJECTED BIG BATTLESHIP.—In conformity with the provisions of the last annual naval appropriation bill, the Secretary of the Navy has sent to Congress the plans of the battleship therein authorized and which must be approved before a contract for its construction can be let. The principal characteristics of the design submitted for approval are described by the Secretary of the Navy as follows:

Specifications:

Length on load water line (about).....510 feet.
Breadth, extreme, at load water line (about).....85 feet 2⅝ inches.
Displacement on trial, not more than.....20,000 tons.
Mean draft to bottom of keel at trial displacement.....27 feet.
Total coal bunker capacity (about).....2300 tons.
Coal carried on trial .....1000 tons.
Feed water carried on trial.....66 tons.
Speed on trial.....21 knots.

Armament:

Main battery—
Ten 12-inch breech-loading rifles.
Secondary battery—
Fourteen 5-inch rapid-fire guns.
Four 3-pounder saluting guns.
Four 1-pounder semiautomatic guns.
Two 3-inch field pieces.
Two machine guns, caliber 0.30.
Two submerged torpedo tubes.

"The hull is protected by a water-line belt of armor 8 feet in width, whose maximum thickness is 11 inches and whose cross-section is uniform throughout the length of the belt. This belt armor gives effective protection to the boilers, machinery, and magazine spaces, and, most important of all, for vessels of this type centers of gravity are necessarily very high, affords in connection with the casemate armor an extensive compartmental subdivision, a reasonable assurance of the maintenance of the stability of the vessel under battle conditions. The side above the main belt armor is protected by armor 7 feet 3 inches wide and of a maximum thickness of

10 inches. This armor is likewise of uniform cross section throughout, and in length is only slightly less than that of the main water-line belt armor. Above the main casement armor amidships the side is protected by armor 5 inches in thickness, which affords protection to the smoke-pipes, the major portion of the secondary battery of 5-inch guns, and the hull structure.

"With particular reference to the offensive qualities of the proposed design, it may be noted that the arrangement of the main battery guns is such as to permit a broadside fire 25 per cent greater than that of the broadside fire of any battleship now built, or, so far as is known, under construction, and the average elevation of the axes of these guns above the water line is believed to be greater than that of any known battleship, thus affording a distinct advantage in long-range firing under all conditions of weather.

"In this connection it may be noted that the percentage of weight allotted to hull and armor is markedly greater than the percentage of such weights allotted to similar purposes in the largest battleship now in existence, and the actual total of such weights is, in the proposed design, approximately 3000 tons greater than in the largest battleship so far built.

"The design provides for a trial speed of 21 knots, and can be arranged for the installation of either reciprocating or turbine machinery, outline specifications for both types of machinery having been prepared. Provision is also made for the stowage of a large amount of oil fuel without in any degree reducing the capacity of the coal bunkers."

The detailed plans and specifications of the battleship have been transmitted to Congress under seal, and it is probable that they will not be made public until, when approved, they are furnished to prospective bidders for their information.—*Iron Age.*

GOVERNMENT VS. PRIVATE YARD CONSTRUCTION.—Below will be found the official statement of the cost of the twin battleships *Connecticut* and *Louisiana*. It will be remembered that the building of the *Louisiana* was awarded the Newport News Shipbuilding & Drydock Co. in open competition, and that the Navy Department decided to have the *Connecticut* built in a navy yard, in order to make a test of the time of construction in a government plant and in a private plant, and also to ascertain the actual cost in each case. Work on the *Connecticut* was begun before the contract for the *Louisiana* was awarded, and the latter vessel was tried under the most exacting conditions and was turned over to the government and went into active service six months before the *Connecticut* went to sea.

This is the official report:

Comparative statement of the cost of construction of the hull and machinery of the U. S. S. *Connecticut* and U. S. S. *Louisiana* to Jan. 1, 1907.

	Connecticut.	*Louisiana.*
Cost of labor and material applied to construction of hull and machinery:		
Under Bureau of Construction and Repair	$2,889,327.89	
Under Bureau of Steam Engineering	1,077,999.98	
Under Bureau of Equipment.	202,925.97	$4,270,253.84
Amount paid to contractor for hull and machinery.....		$3,972,457.00

	Connecticut.	*Louisiana.*
Cost of general superintendence, office expense, etc., at Navy Yard, New York.		All charges of this nature for the *Louisiana* are included in amount paid to contractors.
Under Bureau of C. & R.	94,394.21	
Under Bureau of S. E.	13,490.62	
Under Bureau of Equipment	1,323.17	
Cost of drafting and clerical work:		
Under Bureau of C. & R.	108,520.64	34,245.46
Under Bureau of S. E.	31,310.76	12,897.52
Under Bureau of Equipment	11,622.53	805.28
Cost of inspection at works of sub-contractors for material:		
Under Bureau of C. & R.	3,082.74	3,152.47
Under Bureau of S. E.	1,194.18	1,354.86
Approximate amount due contractors in final settlement		120,000.00
Total cost of hull and machinery (except armor and armament)	$4,535,192.69	$4,144,912.59
Cost of armor	1,562,068.50	1,579,291.05
Cost of turret mounts	242,986.44	256,618.76
Total cost of hull and machinery, including armor and such armament as is chargeable to "Title A, Cost of Construction" (Turret Mounts)	$6,340,247.63	$5,980,822.40

Note.—The difference in cost between the armor of the two ships is stated by the Bureau of Ordnance to be due to the fact that the armor of the *Louisiana* weighed 35.23 tons more than that of the *Connecticut*. The difference in cost of the turret mounts is accounted for by the Bureau of Ordnance and stated to be "owing to the changes, alterations, experiments, and necessary slowness of manufacture as compared with material and designs which have already been manufactured and thoroughly tested out. The excess of $13,632 is not considered great.—*Nautical Gazette.*

ORDNANCE AND GUNNERY. TORPEDOES.

NAVAL BATTLE PRACTICE.—Good as was the progress made in this year's gunlayers' test, which displayed the extra skill and smartness of the men over that of 1905, the long-distance, or combined officers' and men's test promises to be even more progressive and brilliant. It is well known that the battle-practice firing is the most severe gunnery test to which a ship could be subjected. It searches out the weakness of the whole or any part of the fighting organization of a ship from the captain in the conning-tower to the boy in the ammunition supply party. Each and all have to be at their best if a good score is to be made, and above all things there must be a specially good man on the fire-control platform up the mast. From this position the fall of every shot is marked, and the moral instantly seized and passed to the guns. The gunlayer must be quick to seize every advantage and to keep his sights bearing steadily on the object, no matter what motion the ship may have, so that a salvo, broadside, or independent shots, may be sent home on the mark at any moment. One broadside only of a ship is engaged, and she is sent into action by signal, not knowing at what distance she will open fire, or what courses she will steer during the period of her "engagement," a period fixed by the Admiralty.

During this period of time, therefore, the ship under test has to find the range on a constantly altering set of courses, known only at the outset

to the umpires, and to fire at a target as often and as effectively as she can, the officers aloft guiding and assisting the men by "spotting" where the shot fall, and instructing them to raise or lower their sights, while the men have to lay and load their guns as fast as possible during the "engagement." At the end of the run the ships that are marking send to the target and have the actual number of hits counted, and on these the ships are awarded points by the inspector of target practice, Rear-Admiral Sir Percy Scott, and his staff.

The secret of how the points are awarded as between gun and gun, and the distance at which the shots are actually fired, which varies from 4000 to 7000 yards, and how readily the target is found, are the secrets that give the true merit of the performance and hide from foreigners the real nature of the shooting. The comparative results are published each year by the Admiralty, and the conditions of practice are never two years alike, so that one set of rules is not always adhered to, but varied in many ways in order to make the test a severe one, without the experience of any previous year being a guide for the following one. Every year there are alterations and improvements which tend to make the test more searching, so that here, again, the secret of the actual advance made, is known only to those who are aware how much the conditions have been stiffened; and the correct progress cannot be measured by the number of hits made on the target, as the latter only shows the comparative, and not the real progress made by a fleet or a particular ship.

Under the lighter conditions that prevailed in the battle practice of 1905, the flagship of Admiral Sir A. K. Wilson in the Channel fleet, the *Exmouth*, stood first with 374.8 points. How these points were won respectively by the 12-inch and 6-inch guns is not known outside of the Admiralty, but this year it is known that the *Exmouth*, although still in the front rank of good long-distance shooting ships in our navy, has lost the premier place. The first really startling score of this year's competitions was made by the second-class cruiser *Diana*, under Lord Charles Beresford's command on the Mediterranean station. The *Diana* recorded 57 hits. The *Exmouth* followed shortly afterwards with 60 hits, and thus once more headed the fleet. But the flagship of the Channel was soon displaced by the flagship of the Mediterranean, and Lord Charles Beresford's flagship, the *Bulwark*, beat the *Exmouth* by making 62 hits.

This piece of brilliant shooting, which very properly was much lauded at the time, held the field for a few weeks only, and was then eclipsed from a somewhat unexpected quarter. The China station can almost be called the birthplace of the modern gunnery spirit in the British fleet. When the present Inspector of Target Practice, the present Director of Naval Ordnance, and Captain Warrender, R. N., held command of ships in these waters, the British Navy was startled by a series of brilliant scores from the old-time target practice, that eventually kindled the emulation in naval gunnery which has led to present-day results. The China station subsequently sank back into the oblivion from which it sprang, and has lain dormant for many years. Now, however, it has suddenly sprung into life again, and the *King Alfred*, the flagship of Vice-Admiral Sir A. Moore, has recently scored no less than 75 hits, and placed herself ahead of the flagship of the Mediterranean.

Thus it became a battle of the giants, for the flagships were continually coming out on top and setting an admirable example to the others. For thus pulling the China squadron out of the gunnery rut into which it had sunk, too much praise cannot be given to Admiral Moore and his officers and men, for although they are out of that keen gunnery "atmosphere" and rivalry that prevails in the large fleets nearer home, they have shown that great things can still be done in more or less isolated spots, far distant from the emulation inspired by fleets in close contact, and who are striving for first place.

In commenting, however, in a previous article on the splendid scores we

recorded a couple of weeks ago, we prophesied that the end was not yet. That prophecy has now been fulfilled, for overtopping all that has ever been done in the world by way of long-range shooting, another giant, the *Drake*, flagship of Rear-Admiral Prince Louis of Battenberg, in the Second Cruiser squadron, last week, as our pages recorded, made the marvellous score of 105 hits, out of 133 rounds, while carrying out the current year's battle practice.—*United Service Gazette.*

SHOOTING EXTRAORDINARY.—The marvellous piece of battle-practice shooting recently made by the *Drake*, flagship of that enthusiastic gunnery officer, Rear-Admiral Prince Louis of Battenberg, is another instance of what can be done by that zeal which will not be baffled. The gunnery lieutenant of this ship is a young man doing his first commission as a specialist. He has been fortunate enough to meet with superior officers in his ship who backed his zeal and energy with facilities to give them play, and the men of the ship have caught the contagion of the quarterdeck of a real sea-going gunnery ship. It will be well when this spirit of emulation is as thoroughly aroused on every other quarter-deck in the British Navy. The men proved their skill in the gunlayers' test by placing their ship at the head of the list of all the fleets, and the officers have proved that they knew their business by guiding the men to the head of the battle-practice list in the British Navy. Here, then, is an example showing that the system of giving encouragement to the men by money prizes at short distances, and promotion to officers when their ships do well at long distance firing, should be maintained. For following on an indication that the men can shoot well in the gunlayers' test when acting alone, has come the evidence that they also do well under the guidance of their officers at long range, which justifies the present system initiated by the Inspector of Target Practice. And yet there are those who advise the abolition of the short-range test so that long-range firing may be improved by an increased allowance of ammunition.—*United Service Gazette.*

TORPEDO PROTECTION.—Chief Engineer Ferrand, of the French Navy, has recently discussed in an essay the damage sustained by Russian and Japanese warships from the explosion of mines, and the lessons which may be drawn therefrom. He says that on the Japanese side twelve vessels of all classes were injured or sunk by mines, and on the Russian side six sunk and five seriously damaged. M. Ferrand, therefore, concludes that it is the duty of the naval architect to endeavor by all possible means to protect vessels from the consequence of such explosions. There are some who advocate the plan of increasing the number of bilge keels; others propose to place a kind of metallic grating at some distance from the actual hull, making a kind of cage; and others, again, propose to protect the interior of the double bottom with a thin plating, which seems to be the solution adopted by the Japanese Admiralty. The first two solutions are derived from the fact that the importance of the explosion is greatly diminished when the explosive is not in immediate contact with the hull, but in France and England the third solution is favored. M. Ferrand suggests, from an observation made in the case of the *Czarevitch* after being torpedoed, that if provision can be made for the escape of the gases resulting from the explosion in an upward direction within the ship the damage will be on a smaller scale. His suggestion, therefore, is that there should be superimposed upon the actual hull another and lighter hull, placed at a distance of a meter from the true hull, and rising above the water-line whereby the gases of an explosion might escape without doing damage to the actual hull of the vessel. The *Moniteur de la Flotte* states that another well-known authority, who has good grounds for knowing the system of protection adopted in the *Czarevitch*, has proposed a more simple solution which he has patented and submitted to the technical authorities of the Ministry. It has, however, been decided not to employ this means, but to be content with a supplementary armoring of the vessel, as in the case of the *Dread-*

nought. The writer does not know that the *Dreadnought* has for protection against mines anything more than the armoring that is spoken of, but the *Moniteur* tells us that it has good reasons for stating that the three later *Dreadnoughts*—the *Téméraire,* the *Superb,* and the *Bellerophon*—are to be fitted with an arrangement permitting the evacuation of gas in an upward direction in case of the explosion of a mine. The *Moniteur* hopes that the French authorities will follow our example and will reconsider the decision that has been arrived at.—*Army and Navy Gazette.*

COMPARATIVE TRIALS OF ELEVATING GEARS FOR RAPID-FIRE GUN MOUNTS.

The comparative trials of elevating gears in which the gun was moved in elevation by means of (1) a single hand-wheel and (2) by two hand-wheels on the same shaft, extended from May 1, 1906, to December 1, 1906, and included the firing of 25,000 rounds. The trials were conducted with a Bethlehem 6-inch rapid-fire gun.

(a) The two-hand elevating gear consists of two hand-wheels on opposite ends of the same shaft, the handles of the wheels being 180 degrees apart, and the pointer using both hands for controlling the gun. The firing trigger is on the handle of the right-hand wheel and is worked by the index finger of the right hand without releasing the handle. The design and patent of the two-hand elevating gear are the property of the Bethlehem Steel Company, South Bethlehem, Pa., U. S. A.

(b) The two-hand elevating gear when driven by the left-hand wheel only, constitutes the usual form of elevating gear. In this case the firing was done by means of the ordinary pistol grip. A second pointer, pointed the gun in azimuth from the right-hand side in both cases.

(c) Three sets of speed gears were used by each pointer at each range, and for one complete turn of the elevating handwheel moved the gun as follows:

No. 1 Gear 30 minutes of arc.
No. 2 Gear 50 minutes of arc.
No. 3 Gear 75 minutes of arc.

(d) A sub-caliber rifle was rigidly attached to the muzzle of the gun and fired electrically by the firing gear of the big gun.

(e) The targets used, represented a target 26 feet high at the different ranges, and were actually 1.37 inch high for 1500-yard range; .68 inch high for the 3000-yard range; .34 inch high for the 6000-yard range, and .23 inch high for the 9000-yard range.

The target was moved to simulate the continuous rolling of a ship from 1 to 10 degrees by means of a cord, one end of which was fastened to the target and the other end, after passing over a pulley, was moved over a continuous curve.

(f) The curve by which the target was moved up and down simulating the rolling of a ship is made up of semi-circumferences joined together, and the radii of these are of such lengths as to cause the target, and consequently the gun, to move through from 0 degrees to 1 to 10 degrees depression or elevation respectively, and back to 0 degrees again. The time allowed for this (7 seconds) was the same for each roll, and corresponded to a 14-seconds period for the complete oscillation of a ship. The semi-circumferences were sub-divided into two-second periods and a time-bell enabled the operator to pass each mark at the proper time.

Eight gun pointers were in competition throughout the trials, and while the final scores differed slightly, the relative percentages given by the table was practically obtained by each pointer.

(a) Each pointer was allowed a trial shot before each string for adjusting the sight. The distance from the sight telescope to the target was 20 feet.

(b) Each pointer fired for five minutes continuously with a six-seconds loading interval after each shot.

TABLE OF RECORDS.

The total time of firing as between the records for one-hand and two-hands are equal. For example, the time of firing with one and two hands at the 1500-yard target and on the rolls 10°-8° are the same.

		Range 1500 Yards			Range 3000 Yards			Range 6000 Yards			Range 9000 Yards				
		Groups of Rolls			Groups of Rolls			Groups of Rolls			Groups of Rolls				
		10° 9° 8°	7° 6° 5° 4°	3° 2° 1½° 1°	10° 9° 8°	7° 6° 5° 4°	3° 2° 1½° 1°	10° 9° 8°	7° 6° 5° 4°	3° 2° 1½° 1°	10° 9° 8°	7° 6° 5° 4°	3° 2° 1½° 1°		
Total Shots	1 Hand	217	356	580	442	1328	1702	275	1055	1377	240	856	1481	1 Hand	Total
	2 Hands	242	403	642	518	1544	1837	332	1232	1467	290	1042	1589	2 Hands	Shots
Total Hits	1 Hand	153	285	518	225	777	1376	81	442	803	61	286	757	1 Hand	Total
	2 Hands	188	345	582	334	1055	1580	128	553	924	101	437	969	2 Hands	Hits
Gain in Speed of Hitting 2 Hands over 1 in per cents		22.9	21.1	12.3	48.4	35.8	14.9	58.0	25.1	15.1	66.6	52.8	28.0	Gain in Speed of Hitting 2 Hands over 1 in per cents	
Gain in Accuracy 2 Hands over 1 in per cents		10.2	6.9	1.6	26.7	16.8	6.4	30.5	2.5	5.2	37.0	25.5	19.4	Gain in Accuracy 2 Hands over 1 in per cents	

NOTES ON THE PRECEDING TABLE.—For an actual example, which might occur in practice, we take the figures above at 3000 yards range and with the ship rolling from 8° to 10°. Imagine two 6-inch guns side by side, one with a one-handed and the other with a two-handed drive. Suppose these guns fire for the same time, with pointers of the same skill, and at the same target. If 100 represents the number of hits made with the one-handed gun, then 148.4 will represent the hits with the two-handed one. Also, under the same circumstances of firing, the percentages of accuracy show that in expending 100 rounds from a magazine, firing at the same speed as above, we shall get 50.9 hits with the one-handed gun, and 64.5 with the two-handed gun. The other shots will be misses. This latter statement is equivalent to this: when firing at the highest speed convenient to pointers, the expectation of getting a hit with any one shot, in the circumstances defined is, with the one-handed gun 225/442, and with the two-hand gun 334/518. These fractions are the same as .509 and .645.

Also, the figures show an increased rate of hitting with two hands (an increase in the number of hits per minute) under all circumstances from the greatest to the least difficult. When firing at the nearest target (1500 yards) and on the rolls 1°-3°, the increase in the rate of hitting is 12.3 per cent, or for every 100 hits in a given time with the one-handed drive, there will be 112.3 hits with the two-handed drive. When firing at the most distant target (9000 yards) and on the rolls 8°-10°, the increase in the rate of hitting is 66.6 per cent, or for every 100 hits in a given time with the one-handed drive, there will be 166.6 hits with the two-handed drive. As stated, in all cases where the difficulty of the practice is intermediate between these two extremes, the two-handed drive shows more hits per minute than the one-handed drive.

The accuracy of the practice, independently of the speed of firing, is greater in all cases with the two-handed gear. Taking the two extremes of difficulty as before, the record shows that with the 1500-yard range and the rolls 1°-3°, the expectation of hitting with any one shot is, with the one-handed gear, 518/580, or .893, and with the two-handed gear, 582/642, or .907. With the 9000-yard range and rolls 8°-10°, the expectation of hitting with any one shot is, with the one-handed gear, 61/240, or .254, and with the two-handed gear, 101/290, or .348. In considering these last figures it must be remembered that they show only the increase in the probability of hitting with any one shot. The increase in the rate of hitting per minute is greater than these figures, and is as already given above. This is because gun pointers will always fire more shots per minute with the two-handed drive than with the one-handed drive. They get their sight on the target oftener. For example, taking again the circumstances of least and greatest difficulty, the record shows that with the 1500-yard range and in rolls 1°-3°, the number of shots fired with the two-handed gear will be as 642 to 580, as compared with the one-hand gear; or, the two-hand gear gains in speed of firing, 62/580, or .11. At the 9000-yard range, and with the rolls 8°-10°, the number of shots fired with the two-handed gear will be as 290 to 240, as compared with the one-handed gear; or, the two-handed gear gains in speed of firing, 50/240, or .21. The table of records shows that there is no interruption in the laws of accuracy and speed here shown.

It is to be noted that the results as to accuracy and speed of firing here shown cannot be reached in actual practice with targets at a distance. As the targets were only four feet from the muzzle of the small gun used, the bullets went straight to them, and all inaccuracies due to imperfections in powder and knowledge of range are eliminated. The records show what might be attained if muzzle velocities were very much greater than they are and were maintained, and measure therefore only the accuracy attainable by pointers with service sight and service arrangements for handling the gun.

Gain in Accuracy 2 Hands over 1 in per cents	10.2	6.9	1.6	20.7	16.8	6.4	30.5	9.5	5.2	37.0	35.5	19.4	Gain in Accuracy 2 Hands over 1 in per cents

GENERAL CONCLUSIONS.—The better results obtained by the two-hand elevating gear as shown by the table are accounted for by the following conditions:

(1) The gun can be worked faster with two hands than with one, and the larger the gun the greater the advantages.

(2) The gun can be kept on the target better on account of the ease with which it may be stopped, started or reversed.

(3) The motion of the gun is smoother on account of the greater power to overcome tight places in the gears and also the absence of a dead center with the two-hand drive.

(4) The motion of the gun pointer's body is less with the two-hand drive, and the eye can be kept constantly at the telescope.

MARINE TURBINES AND GAS ENGINES.

MARINE TURBINES IN SERVICE. (By Robert S. Riley).—With most engineers, not directly associated with turbines, the idea prevails that once a turbine is set up and running that is about all there is to it—that is, it has no individuality such as a reciprocating engine has, for everyone knows that a reciprocating engine has numerous personalities peculiar to itself. Some engines give trouble with the valve gear, others in the guides; another may have a pet crank pin that requires special attention, and so on to a legion of more or less important details, which every engineer has to study for each engine of which he takes charge.

It is true that the running part of a turbine consists simply of a revolving rotor. But there are other moving parts. In fact, with the refinement of clearances due to this method of using steam, almost every part of the entire turbine has to be considered a moving part, with a motion of its own. Contraction and expansion measure the extent of this movement, and any change of temperature supplies the necessary motive power. It will be seen, therefore, that this opens up a world of personalities in a turbine, which may be fully as complex as the vagaries of a quadruple expansion reciprocating engine. Every engineer knows that the behavior of an engine will vary with the speed, sometimes valve-gear and piston rods giving more trouble at low speed than at high. These peculiarities of a reciprocating engine have been the subject of careful study, and long experience has shown how to provide for them. Besides this, the big high speed engines have been through such a process of evolution that each change or addition has not been very radical.

However, in the case of the turbine, designers have been forced at once into competition with reciprocating engines that have been the product of years of study to get them to their present size and efficiency. Naturally this results in some crudities, which experience and study may eliminate. To a certain extent, therefore, all turbines built are experimental as yet, but each gets nearer the future standard, and adds its quota to the general fund of information. Not that a turbine built to-day may become obsolete a few years hence; the general principles are established and will not change, but many details will. It is not probable, for instance, that old turbines will be displaced as old automobiles have been, for the latter are more or less of an undeveloped commodity, and their use gives rise to more notions each day; whereas the mission of the turbine is pretty clearly defined. It is to take the place of high-speed reciprocating engines, and do the work that they have done so completely for years.

There are now quite a number of sea-going turbine engineers, practically all of whom are in charge of Parsons turbines, as this is the only type as yet in general use on board ship. Talking over troubles and peculiarities with these men brings out the fact that there is a good deal more to be looked after than is generally supposed. For one thing the speeds are high and lubrication correspondingly more important. The two main bearings

of each turbine are kept floating in oil under pressure. This is very essential, for if ever the metals should come into intimate contact without a film of oil interposed, the friction would soon be fatal. This has occurred in one turbine job, with the result that the metal promptly melted, the alignment was thrown out, the blades of the rotor fouled those of the stator, and hundreds of them were stripped. This happened on the American coast, and an expert blader had to be sent from England to fit new blades.

This forced lubrication is therefore an added responsibility for the engineer, as it involves another complete system. The larger ships have this in duplicate, so great is its importance. But perhaps the greatest additional care required in lubrication come in the shaft alley. The forced lubrication takes care of the turbine bearings proper, but thus far has not been extended to the spring bearings. These bearings are generally a source of considerable anxiety. Water has to be used freely, and even then the temperatures are excessive.

It is a good thing that the line shafts can be made so much lighter and still transmit the same power as a slower speeded shaft. This offsets, to some extent, the tendency of a shaft to heat, due to its own weight and rigidity in resisting motions of the ship.

One bearing, however, may be excepted from the general tendency to give more trouble than the reciprocating engine's, and that is the thrust. Here is an ideal condition, where the thrust of the propeller on the water is directly opposed by the thrust of the steam on the forward sides of the blades of the rotor. Conversely, when going astern, the pull of the propeller is opposed by the forward pressure of the steam on the go-astern blades.

The auxiliary machinery for circulating and air pumps is much larger than would be required with a corresponding set of reciprocating engines. This is due to the great importance of high vacuum in the economy of the turbine. The addition of intensifiers, or of dry air pumps, further complicates the engine room equipment. The intensifier is practically another small condenser for a steam siphon which increases the vacuum in the main condenser. This additional vacuum is held in the main condenser by means of a differential water seal in the pipe connecting the two condensers. The dry air pumps are likely to be finer pieces of machinery than ordinary air pumps. Their valves are positively driven, instead of automatically.

We hear a good deal of the successful working of the turbine, and very little of its troubles. Nevertheless the latter occur. Sometimes the most trivial change in normal conditions causes an abnormal contraction or expansion, and the blades foul. For instance, one steamer had been in successful operation for over two years; the low pressure turbines had been running "dead slow" in a fog for one hour, longer than they had ever been before, so that they were running on cold vapor, and were quite cold from end to end. An order came for "full speed astern." The rush of hot steam through the astern blades of the rotor shell caused a sudden expansion, and blades that had cleared for two years, fouled and wrecked themselves, putting one turbine out of commission instantly, though nothing appeared on the outside to indicate anything wrong.

Another case occurred on a liner which had run successfully for some months. The propellers were changed from four to three bladed, with consequent speeding up of the turbines above the designed speed. In setting a governor, it is supposed that one low-pressure turbine ran a few revolutions above the maximum allowed. The construction of the rotor drum was such that the butt straps holding together the plates of which it was composed, formed a powerful moment under the action of centrifugal force. The circumference of the shell was distorted, and the blades touched and were stripped.

As an offset to the liability of injury to the blades it may be said that

turbines run practically as well with a large number removed. Thus, in the two cases just cited, the covers were lifted at the first opportunity and the stripped blades removed from casing and rotor. It was impractical to re-blade them at the time, so the casings were replaced with the blades missing. No serious difference was noticed, and each ship did its duty until an opportunity arrived for re-blading.

An interesting case of this kind happened recently in a stationary plant. A large number of blades were stripped; the casing and rotor were lifted immediately, and the stripped blades removed. The turbine was started again and ran continuously, each working day, without further trouble. Each night the cover and rotor were lifted and a ring or two of blades inserted until they were all complete again. It is doubtful if any job of similar magnitude could be done in instalments thus on a reciprocating engine.

Most men in charge of turbines claim that it is a "chief engineer's job"; that is, the final responsibility rests on one man, and he cannot delegate it to the same extent that can be done with a reciprocating engine. There is no chance to "take leads" to bring up and show the chief how things are running. If he has reason to question the clearance of blades anywhere, he must spend anxious minutes with his ear on the casing, while the turbine is speeded up cautiously, listening intently for the faintest sound of interference. Adjustments can be made to allow for the wearing down of the main bearings, but this is very seldom required with perfect lubrication. Each case of adjustment calls for renewed careful listening and cautious speeding up, for once a blade touches strongly enough to bend it, they all go down like nine pins, and a "ten strike" is easily made.

An obstruction accidentally left in the casing would mean ruin to the blades, if it were swept into them by the rush of steam. Even a small piece of waste, or an overall button would be sufficient to start a "ten strike." As these casings at the condenser end are sometimes large caverns into which men go for observation, it will be seen that the man responsible will be pretty careful not to let anything drop or be left behind by mistake.

Taking it all together, however, the turbine men are agreed that they would rather take care of a turbine than almost any reciprocating engine. There are fewer details to worry about, and those that do give trouble are apt to be strictly "up to" the designer, rather than to the operating engineer.

Probably the method of fastening the blades is the most critical point at present. Great improvements have been made, however, and it is likely that the problem will soon be satisfactorily solved. It is all expert work, and the average operating engineer is not likely to have much to do with it. Experience will probably develop the art to such an extent that stripped blades will be very rare. The clearance spaces are already considered of less moment than formerly, and this relieves much of the danger of fouling. Improved facilities for finishing the ends of the blades or shroud rings will leave them less liable to fouling. There is also quite an art in the design of casings so that they will not change form too radically upon the application of heat.

As regards the handling and maneuvering of the turbine, it is much simpler and less hazardous than with reciprocating engines. There are no drains which, if forgotten, might knock out a cylinder head. The time required for "warming up" is much less, for steam has access to all parts at once. This, of course, is of great advantage when standing by for departure or "up anchor." The high-pressure turbine, in the prevailing arrangement of three turbines, is not touched at all in maneuvering or getting away, and it is the first to be shut off on an arrival "stand-by." Sometimes this turbine has no separate telegraph control for taking orders from the bridge, the engineer simply turning it on when he gets his jingle for right away. When fitted with a telegraph there are no "go astern" signals, of course, and such a telegraph dial looks odd at first sight.

The low pressure turbines are the only ones fitted with reversing blades, and so, of course, are the only ones worked to bells. Their operation is very simple, for the levers are arranged so that the cut off from the high pressure turbine is automatic. When maneuvering, the engineer has to depend on the governor balls to show when the turbine moves, for there is nothing visible to correspond with the numerous moving parts of the reciprocating engine. The turbines start quite promptly on the inlet of steam, and soon speed up. The regulation of speed according to orders is done by maintaining given pressures in the steam pipes. When shut off, the turbines do not stop so promptly, for the inertia carries them around until overcome by friction. For a quick stop the steam is turned into the astern side to help bring up the turbines. In case of a sudden order from "full ahead" to "full astern," the steam is instantly switched from the ahead to the astern blades, with no thought of the racking that would occur to reciprocating engines if they were treated thus. The turbines soon bring up under such treatment and in a few seconds are running just as fast astern. The smaller propellers, of course, are not so hard to reverse as would be the larger ones of a reciprocating engine, and, conversely, do not take such a grip on the water. That is, they start a column of water in movement promptly enough, but it is not of large diameter, and is not so quickly felt by the ship.

Much attention is being paid to this reversing feature of the turbine propeller. Recent turbines are built with almost as many go-astern blades as they have on the go-ahead side. They are on a smaller radius, the expansion is not so complete, but they use high pressure steam and the power is there, even if not quite so efficient. The result is that turbine ships can now stop about as quickly as any other. For maneuvering it must also be borne in mind that the turbine propellers are set away out from the center line of the ship. This gives a greater turning moment in case of swinging the ship about.

There are arguments on both sides of this turbine question, all of which may appeal differently to different engineers. Here is about the way they line up to the men who run them:

ADVANTAGES.

More room in the engine room, especially head room.

No moving parts exposed. Consequently no danger of getting caught, due either to lack of care, or to accident, and no oil thrown around.

No vibration of the ship, hence pipe hangers, joints, etc., do not shake loose.

Lighter shafting in engine and alleys.

Balanced thrust; smaller bearing and less heating of same.

Foundations of the engine lighter and more accessible.

No oil carried through to boilers, and oil saved due to increased efficiency of application.

No danger due to foaming or priming of boilers.

Less attendance required on engines, nearly everything being automatic.

Better immersion of smaller propellers, hence no racing in a sea way.

Less steam pressure. High vacuum is easier and more comfortable to handle than high steam.

Turbines easily turned when cold, and less likely to need it.

DISADVANTAGES.

Moving parts not accessible and not visible, so you don't know what is going on inside.

Auxiliary machinery larger and more important, hence more care.

More dependence on automatic lubricating system for bearings.

At least one more line shaft to care for, and all of them at higher speed and more apt to run hot.

Main casings and rotor very heavy to handle, and great care required even with best appliances on new ships.

Danger of disablement by unseen causes among the blades.

Difficulty in making repairs to blades.—*International Marine Engineering.*

THE COMPARATIVE COST OF MARINE TURBINES AND RECIPROCATING ENGINES.—While data as to the cost of steam-turbines for land stations show a considerable saving as compared with reciprocating engines, it has not so far been possible to establish the same advantage in connection with marine installations. This is due in part to the less extensive application of the system, and to the variable conditions being inimical to direct comparison. The prices asked by contractors for the machinery of warships afford, perhaps, the fairest basis of arriving at the relative costs. For the boilers and turbines of three new *Dreadnoughts* to develop 23,000 shaft horsepower, the tenders, including the auxiliaries, ranged from £11.13 per horsepower to £14—wide limits, due to the present condition of the industry and to the degree of experience of turbine manufacture by the respective firms. It is, however, significant that four firms who have made machinery of this type quoted between £11.13 and £11.35 per horsepower; and thus the machinery of the *Superb* to be built at Elswick, will be constructed by the Wallsend Company, while the Fairfield Company and Messrs. Hawthorn, Leslie & Co. will make the machinery for the *Téméraire* and *Bellerophon* respectively, to be built in the dockyard. The price paid for the reciprocating engines of the five dock-yard-built vessels of the *King Edward VII* class ranged between £11.7 and £12.5 per indicated horsepower. The average per shaft horsepower would be about £12.2, so that we have in turbine machinery a saving of between 15s. and 20s. per horsepower. When it is noted that the aggregate power is 23,000 horsepower, the total saving is considerable. The machinery of the modern battleship *Agamemnon*, with reciprocating engines, also comes out at £12.1 per horsepower. In the case of the latest of armored cruisers, with reciprocating engines, the price averages £10.6 per horsepower, and here the power is the same as in the new *Dreadnoughts*. What is certain, therefore, is that, notwithstanding the necessity for additional turbines for cruising, turbine machinery for warships costs probably less than reciprocating engines. In the merchant service, where no cruising turbines are required, the cost is already considerably less; with experience there will be appreciable reductions.—*Engineering.*

BOOM IN MARINE TURBINES.—Before the new year is many months old no less than five of the greater shipbuilding companies on the Tyne will have completed the laying down of plant for the production of turbines, of course under license from the original patentees the Parsons' Marine Steam Turbine Co., Ltd., whose works are at Wallsend. The Wallsend Slipway and Engineering Co. and Messrs. Hawthorn, Leslie & Co., are already in the field, the former having secured the important contracts for supplying turbine machinery to the liner *Mauretiana* and H. M. S. *Superb*, the new *Dreadnought*. To these must now be added the Palmer Co. at Jarrow and the Armstrong-Whitworth Co. at Elswick. The former has its new plant well on the way, and at Scotswood-on-Tyne an extensive steel shop is in course of erection for Armstrong. Whitworth & Co., who design the new works solely for the production of the largest type of turbines. As nearly a thousand hands are expected to be employed in this one new department alone, it is easy to see that these developments will collectively make a very important addition to wage-earning occupations on the Tyne.—*Manchester, Eng., Guardian.*

GAS-ENGINES AND MARINE PROPULSION.—From time to time, as advances are made in gas-engine practice, the question of the use of such engines for marine propulsion is raised. As one difficulty after another is removed by improvements or new systems, we reach a stage nearer the goal. It is evident that sure advances are being made in the right direction, but the difficulties still are many, and the steps somewhat small and slow, compared with the distance to be traversed. For instance, we take up a paper—plenty of them have been submitted to societies and institutions—and read about the application of gas-engines to ships. We hear of schemes for sets of engines capable of developing 3600, 5000, or more horsepower, and all sounds well; but we also know that the largest amount of power yet installed in the form of gas-engines on board ship is only a mere fraction of these amounts. For this discrepancy there must be good reason, especially as the names of many able men are connected with the study of this problem.

The chief difficulties encountered in this matter arise from the necessity for any system of marine propulsion being adaptable to a large variety of circumstances, and, if the expression may be used, elastic in nature.

In the matter of fuel the system chosen must be suited to the supply obtainable in all parts of the world. In the matter of power it is necessary that there should be a wide range for working under all conditions of weather and circumstances; and in the matter of handling, the engines should be prompt and easy to reverse, and, in fact, perform all the duties at present carried out by steam. With regard to the first it is futile to equip a vessel with a gas-producer plant using anthracite. The only fuel possible is bituminous coal, and that, too, in extremely variable qualities. But the producer must be prepared to use these different qualities with, at least, something approaching success. We are told that producers for bituminous coal have now been successfully designed, in which the various accessory appliances are either simplified or altogether abolished. Others have suggested the provision of coke-burning producers, the coke being made on board; this, however, usually being condemned as too cumbrous. It is by no means improbable that this producer difficulty, as well as others, will be surmounted. The subject is making rapid strides, and will no doubt develop to a degree which it is at present difficult to gauge.

Given a successful producer capable of using any grade of bituminous coal, there still remain such difficulties as reversing and reduction of power. This problem has been attacked in several ways, but with results as yet not wholly satisfactory. Indeed, the choice at present rather falls upon that which is the least crude, rather than that which is best. Reversing may be done by the propeller, but this only with small vessels; or it may be managed by rotating the cam-shaft. Again, by adding considerably to the equipment it may be managed by electrical driving, or the result may be attained by the system suggested by Mr. J. T. Milton, M. Inst. C. E., in his recent paper before the Institution of Civil Engineers. Again, a suggestion has been put forth by Mr. A. Vennel Coster, in a paper before the Manchester Association of Engineers, that, with three sets of engines, in order to reduce power or bring a vessel to rest, one screw might be reversed while the other two still went ahead, and so on.

In the electrical drive, in which a gas-engine drives a dynamo, connected up to a motor on the propeller-shaft, the horsepower of machinery to be paid for is three times that required to drive the vessel. In Mr. Milton's system of separate engine and compressor, with the example he gives of a 3250 indicated horsepower engine, compressing gear requiring about 1450 horsepower is necessary. Thus the machinery paid for amounts to 6150 horsepower, while the net output of the installation is 3250 horsepower. Of course, the propelling engine, being on the two-cycle system, would be relatively cheap. Machinery comprising eight or eleven cylinders, together with all moving parts, etc., does not impress one favorably. Mr. Milton's plan includes three expansion cylinders 25½ inches in diameter for the pro-

pelling engines. For the compressors two double-acting air cylinders 31 inches in diameter and two double-acting air-cylinders 18 inches in diameter for the first and second stages of a two-stage compressor may be chosen, this being driven by a four-cylinder tandem gas-engine, of cylinders 24½ inches in diameter. As an alternative, it is suggested to complete the second stage of the compression in one cylinder, 25 inches in diameter, instead of two of 18 inches, and to drive the compressor, a tandem two-cylinder engine, cylinders 34½ inches in diameter.

Mr. Vennel Coster's system appears to us no less unsatisfactory. His proposal certainly involves no large auxiliary plant of compressors and driving-engines; but to keep engines going full speed ahead and to counteract their effect by running other engines full speed astern seems a most unmechanical method of surmounting these difficulties. It is probable that the efficient reduction of mean pressure may be attained by fairly satisfactory methods, this being possible by Mr. Milton's plan, and, it would appear also, by certain other means. The chief difficulty, of course, in this is in the fact that the poor mixtures are difficult to ignite. With tandem vertical cylinders 50 per cent reduction of power is possible by cutting out certain cylinders. Reduction of power below a certain point renders the engine liable to stop, no fly wheels, or only very small ones, being possible in marine work.

A further difficulty which presents itself to the economical mind is the use to be made of gas from the producer when the engines are not required. On ceasing to draw gas for the purpose of running the engines, the temperature of the producers must be maintained by continuing the gas production. Something must be done with this. Mr. Coster uses it by running his engines at full speed, one counteracting the others. Mr. Milton makes no suggestion on this point, and we presume that that not required for driving his compressor plant would be allowed to run to waste.

Altogether, the problem is one full of knotty points. Although we are talking airily of installations of many thousands of horsepower, and are only building a few of a few hundred, and while the difficulties that suggest themselves at present appear, on present knowledge, difficult to surmount satisfactorily, we do not doubt that as progress is made, these will all disappear one after another. There is quite possibly a great future before this form of propulsion for marine purposes, but it would seem to be well to be not too ambitious till matters are a little more advanced. The two branches of the subject of producers and gas-engines are, as yet, not far advanced even in land practice, and experiment in marine work might well seem more advisable in schemes of moderate size than on the lines recommended by many recent writers on the subject, whose great aim appears to be mainly to obtain (on paper) some combination of cylinders capable of giving so many horsepower.—*Engineering.*

MARINE ENGINEERING IN 1906.—Just as in the case of heavier ordnance and other armament development rendering the term tonnage less fitting than it was as a measure of the fighting efficiency of naval ships, so now the term indicated horsepower less than ever conveys an adequate measure of the efficiency and character of their propulsive machinery. Turbines, water-tube boilers, oil-firing, and other matters are undefined factors in the case which require some individual reference. That the Admiralty are quite satisfied with the results of the *Dreadnought's* trials—the fact of this great "engine of war" having been launched, tried, and commissioned within the year should make 1906 memorable as the *Dreadnought* year—is evidenced by the fact that the three ships to be started in the financial year 1906-7 are practically to be repetitions of her. The *Dreadnought's* turbine machinery was made by Mr. Parsons' firm under a sub-contract with Vickers Sons & Maxim. The three cruiser battleships, *Invincible, Inflexible* and *Indomitable,* now being built by contract, are each to be engined on the same system as the *Dreadnought* the power being about

40,000, and the speed 25 knots. In these and other smaller vessels of the destroyer type the Parsons turbine is supreme.

The naval authorities of other countries, although they have not committed themselves decisively to anything very large in the way of the application of the turbine—either of the Parsons' or other type—have during the past year not been listless. The United States authorities are awaiting the results of experiments which they have been making with cruisers fitted with Parsons' and with the Curtis types of turbines, and besides being greatly impressed with the intrepidity of this country in connection with the *Dreadnought* and with the express Cunarders they are also awaiting results in these directions. The German naval authorities also look to the bold British ventures to afford them guidance, while they meantime undertake experiments of their own. Their first turbine boat, the cruiser *Lübeck* has been generally successful, and turbines are to be fitted to one of the large cruisers in the 1907 program. The French and Russian governments have decided to adopt turbines in battleships, and the Italian government are fitting turbines by Parsons in the armored cruiser *San Marco*, now being built at Castellamare.

The increasing and projected further use of oil fuel in the navy is also a line of development which the year's experience has more definitely made clear. All the large ships have oil fuel fittings and storage for a large quantity of oil fuel, which will greatly increase their radius of action, besides reducing—like the employment of turbines—the machinery staff required. The projected destroyers are arranged solely for oil fuel.

Concurrently with the increase in dimensions and power of ocean steamships, and almost a necessary complement of it, the outstanding technical feature in marine engineering has, of course, been the advance made in turbine design and manufacture, and in the accumulation of experience of the system in daily working. Of the great Cunard liners *Lusitania* and *Mauretania*, launched during the year, and described at length in our columns, and of the turbine machinery now being installed on board, it is here unnecessary to say anything. In this connection, an article appearing in our impression for January 18 on "Steamship Anticipations for 1907" may be referred to. The recent examination and refitting of the *Carmania's* machinery, after a year's working, yielded both a guarantee of the soundness of the new mode of propulsion in such huge units, and a store of guidance for further and greater achievements in the same pathway. Apart from the two 33,000-ton Cunarders and the 17,900-ton battleship *Dreadnought* the year's contribution to the number of turbine-propelled vessels is not remarkable. Seven of the vessels were for channel and river service, and the promise of rapid development in the adoption of the turbine for channel service is every day growing stronger. The two steamers which W. Denny & Brothers of Dumbarton, are building for the South-eastern & Chatham Railway Company's service are to be ready for this summer's traffic, and the turbine fleets in the English channel and other arenas should this year present a notable object-lesson to those railway companies which are still adhering to the reciprocating engine. Only the Lancashire & Yorkshire, the London & Southwestern, and the Great Eastern are now in this category, but it is rumored that the two latter will put turbines into their next new steamers. The fast turbine steamers built and being built by the well-known Cockerill Company for the Belgian service between Ostend and Dover need only be mentioned. The most notable advance during 1906 was made in foreign countries, where, however, the stage has only been reached which Britain had arrived at five years ago. During the year well-known companies in France, Belgium, Russia, Japan, and the United States took out licenses to manufacture the Parsons turbine, although, of course, in this country this right has been arranged for by almost every British engineering firm of standing, this entailing, in most cases, the laying down of expensive new plant for the purpose. America produced her first turbine-propelled steamer

during the year—the *Governor Cobb*—and she was placed on the Boston and St. John's (N. S.) route at a time nearly corresponding to the placing on the Clyde service, five years ago, of the pioneer passenger turbine steamer *King Edward*. The American vessel has three Parsons turbines of 5000 indicated horsepower made by the Fletcher Company, of Hoboken, N. J. Two other turbines are being built at the same yards for the New York-Boston service, and one is being built at Bath, Maine, for coastwise service.

The obstacles in the way of properly accommodating or wedding the rapidly-moving efficient turbine to the slow-moving efficient screw propeller have not been materially lessened or changed by the experience acquired of late, and Mr. Parsons' proposed adaptation of the turbine and the reciprocating engine, in which the turbine would utilize the steam after doing its work in the cylinders of the reciprocating engine, has not so far declared itself in practice. This adaptation, he estimates, will save from 15 to 20 per cent in the cost of coal, and Mr. Parsons himself expects to see, in actual service, very shortly, a vessel fitted in this way. Both for naval purposes at low speeds, in vessels primarily designed for high speeds, and for the slower classes of merchant ships, the combination proposed will soon be tried, and its value attested in actual service.

The movement for propelling trading vessels of moderate size by internal-combustion engines of one type or other—suction gas, petrol, paraffin, etc.—has not been very materially advanced during the year by anything actually done in this country, but on the Continent various partially successful, and on the whole very promising, trials have been carried out. On the Clyde the firm of Beardmore continue to experiment with engines of the *Capitaine* type using producer gas, and this year, no doubt, definite progress will be made. A small trading vessel. motor-propelled, and carrying some 200 tons, has been running for some time between Swansea and Avonmouth, and the Ailsa Shipbuilding Company, of Troon, has on hand for MacBrayne's, of Glasgow, a vessel of 100 feet in length, to be propelled by motor, and do trading service in the West Highlands. Of course, for pleasure and tender services motor boats are now a common product, and marvellous results are being attained by Thornycroft, Yarrow, White, and the other noted builders of such craft. Motor vedette boats are now being built for the new *Dreadnoughts* which are 51 feet over all, and it is estimated that an internal combustion engine, specially constructed to work with the same fuel as in the battleship's boilers, of 250 horsepower, will give the same results, as to speed and its cost, as the steam engines and boiler of 350 horsepower which would otherwise have been installed. For the successful motor engines which home firms are now turning out in great numbers, this country has, no doubt, largely to thank other countries. Both in German and Dutch waters steam has been almost entirely superseded by motor power in small installations. That we should not be content to allow our continental friends to lead in the larger and more utilitarian installations as well must be the care of British engineers.—*Engineer.*

RADIO-TELEGRAPHY.

THE INTERNATIONAL WIRELESS TELEGRAPH CONVENTION.—At the Wireless Telegraph Convention which was held in Berlin during last October, a "Final Protocol" was arranged by the representatives of the following countries: The Argentine Republic, Austria, Belgium, Brazil, Bulgaria, Chili, Denmark, France, Germany, Great Britain, Greece, Hungary, Italy, Japan, Mexico, Monaco, the Netherlands, Norway, Persia, Portugal, Roumania, Russia, Spain, Sweden, Turkey, the United States of America, and Uruguay. According to the agreements which is placed in the form of 23 articles, coast stations and ship stations are bound to exchange radio-tele-

grams reciprocally without regard to the particular system of radio-telegraphy adopted by these stations. Notwithstanding this provision, however, a station may be appropriated to a service of public correspondence of a restricted character, determined by the object of the correspondence, or by other circumstances independent of the system employed.

It is arranged that the working of radio-telegraph stations shall be organized, as far as possible, in such a manner as not to interfere with the working of other stations of the kind; and that radio-telegraph stations are bound to accept with absolute priority calls of distress from ships, to answer such calls with similar priority and to take the necessary steps with regard to them.

The provisions of the convention come into operation on and from July 1, 1908, and remain in force for an indefinite period or until the expiration of a year from the date of denunciation.

All of the above-named countries, with the exception of Great Britain and Italy agreed to 42 additional regulations dealing with the service operation of the wireless equipments. According to these regulations the choice of apparatus to be used by the station is unrestricted, but only two wave-lengths, namely 300 and 600 meters, respectively, are allowed for general correspondence; for special long-distance service each government may authorize the use of wave lengths between 600 and 1000 meters. The normal wave length for ship stations is 300 meters. Each ship station must be installed in such a way as to be capable of using this wave length. Other wave lengths may be used by these stations on condition that they do not exceed 600 meters. Ships of small tonnage, which it would be materially impossible to equip with plant producing a wave length of 300 meters, may be authorized to use a shorter wave length.

Ship stations must be licensed by the country whose flag they fly. They must use a syntonized system working with power not exceeding normally 1 kw. at not less than 12 words per minute, and they must carry a certificated telegraphist bound to secrecy. The order of precedence for telegrams is (1) messages to or from ships in distress; (2) government messages; (3) service telegrams and (4) private telegrams. There are in addition regulations as to the calling and responding of wireless stations, order of transmission, the division of charges and the usual minutiæ of a telegraph service.—*Electrical World.*

TRANS-ATLANTIC WIRELESS TELEGRAPHY.—In 1904 the National Electric Signalling Company decided to erect two stations for trans-Atlantic working, the antennæ to consist of cylindrical steel tubes, 400 feet high, with the National Electric Signalling Company's patent umbrella capacity at the top, each tube to rest at the bottom on a pivoted insulated base, and to be supported by sectionally-insulated wire-rope guys of the company's standard type. This type of antennæ, which was invented and designed by the National Electric Signalling Company, and patented by it, has proved quite successful, and has been copied in Germany at the Nauen wireless station, a lattice-work, however, being used instead of a steel cylinder.

The sites selected were Brant Rock, 30 miles south of Boston, Massachusetts, U. S. A., and Machrihanish, on the far side of the Mull of Cantyre from Campbelltown, Scotland. These two points were selected because the great circle joining them passes up the Bay of Fundy, over the Isthmus of Chignecto, and across Newfoundland at a point where it is comparatively low. The contract for the steelwork and erection of these towers was let to the Brown Hoisting Machinery Company, of Cleveland, Ohio, U. S. A., and for the insulators to the Locke Insulator Company, of Victor, N. Y., U. S. A. Owing to delays on the part of the contractors, the towers were not completed until December 28, 1905.

On Friday, December 29, 1905, Brant Rock sent to Machrihanish, but nothing was received, owing, as it was afterwards learned, to a miscalcu-

lation in the wave length. On January 2, 1906, Brant Rock sent again, and Machrihanish received the messages. Communication was maintained one way until about the middle of January, when, the sending apparatus at Machrihanish having been completed, Machrihanish sent, and Brant Rock received messages from there at the first trial. Very satisfactory communication was then maintained for some time, and code messages containing as many as forty cipher words were received without a single error, or the necessity of any repetitions.

It was found that the amount of atmospheric absorption had been miscalculated. From tests made on shipboard at distances of 1500 miles, the atmospheric absorption had been found to be about 90 per cent—*i. e.*, 10 per cent of the radiation got through. It was considered that by assuming the atmospheric absorption to be 99 per cent—*i. e.*, that 1 per cent of the radiation got through—a sufficient factor of safety would be provided. As the design was conservative, it was found that in practice the factor of safety was larger than this, and equivalent to an absorption of 99.8 per cent—*i. e.*, that messages could be received although one-fifth of 1 per cent got through. Over this distance of 3000 miles, partly over land, it was found that the absorption was considerably greater than this, and that as a matter of fact, during daylight, not more than one-tenth of 1 per cent of the energy got through, and that a factor of safety of at least 100,000 must be provided.

As an illustration, with the same sending power, on some nights messages were received 480 times stronger than was necessary for audibility, and the messages could be read with the receiver 6 inches away from the ear. On other nights with the same sending power, the messages were so faint that they could not be read. A number of tests were made, which were witnessed by scientific experts from the General Electric Company in America, and Mr. Shields, the technical expert of Messrs. Abel and Imray, and others; but as it was evident that the stations were not sufficiently powerful for commercial work, they were shut down early in 1906, for reconstruction.

Owing to the impossibility of getting aluminum for the compressed air condensers the stations were not opened again until October, 1906, when they were operated at a factor of safety of 2000, only half of the condensers being in place. With the full amount of condensers the factor of safety would have been 4000, and a new form of receiving apparatus, which it was intended to use, would have brought up the factor of safety to 400,000. The stations operated continuously, barring shut-downs for a couple of nights for mechanical reasons, until December 5, when the tower at Machrihanish blew down. This accident came at a very unfortunate time, as work had just been begun on a new method for eliminating the atmospheric absorption, which had given very promising results, the absorption having been already reduced to one-tenth of what it was formerly. Moreover, the new receiving apparatus had only been partly installed, and no opportunity had been afforded of trying it between the trans-Atlantic stations.

The specifications on which the contractors bid called for the tower to stand a wind-pressure of 50 pounds per square foot on a flat surface, and for the tower to be capable of being extended to a height of 500 feet later, if desired, and to be capable of standing a pressure of 50 pounds per square foot on a flat surface even if one set of guys broke.—*Engineering.*

A DEVELOPMENT IN RADIO-TELEGRAPHY.—A result for which many have sought in radio-telegraphy is that of producing undamped electrical oscillations of fixed frequency. A successful method of doing this would reduce the problem of tuning to a simple matter and would at the same time greatly increase the power of a given system, since it would make possible the utilization of a train of waves to actuate the receiving device, whereas with the ordinary methods where damping occurs dependence must be

placed upon the energy of the first wave. Many have attempted the solution of this important problem, with more or less success. The latest contribution to this work has been made by Valdemar Poulsen, who is well known as the inventor of the telegraphone. that device which registers a telephone conversation on a steel disc or wire.

The line of attack adopted by Poulsen was begun by Duddell, who made an exhaustive study of the socalled singing arc. When the electric arc is shunted by a circuit containing capacity and inductance electrical oscillations may be set up around the circuit, the frequency depending upon the constants of the circuit and the conditions at the arc. Such a circuit becomes, then, a source of continued oscillations, which might be of value in wireless telegraphy, if the frequency of the oscillations can be carried high enough and if this frequency can be made sufficiently constant. Duddell succeeded in reaching from thirty to forty thousand oscillations per second, which was not sufficiently rapid. Poulsen, starting from this point, has, by making a careful study of the arc, carried the frequency to about 700,000 per second. He accomplishes this by surrounding the arc with hydrogen gas containing a small amount of hydrocarbon vapor. This frequency is sufficiently high for use in wireless telegraphy, so that the problem is thus partially solved. It remained to operate the arc under conditions which would give a constant frequency, which was finally done by holding the arc in a fixed position by means of a magnetic field, which, as is known, repels the arc; and by constructing the electrodes so as to maintain the length of the arc rigidly constant. To prevent changes in length due to the action of the arc on the electrodes the positive electrode is made of copper and kept cooled by circulating water through it; while the negative is made of carbon of larger size with a sharp edge, and is kept revolving at a slow speed so as to present constantly a new point of contact to the arc.

With this device it is possible, according to Poulsen, to obtain oscillations of any frequency desired, and at the same time to hold the frequency constant, so that tuning within one per cent is easily obtained. The few practical tests which have been made public agree with this assertion, since communication was maintained over considerable distances with the expenditure of a small amount of power at the transmitting station. It would seem that the new method of generating electrical waves should be of the greatest importance in this comparatively new art.

There are several advantages with such a system. First, the use of undamped waves of fixed frequency makes accurate tuning possible and makes it possible also to operate a large number of stations within a given district without interference. This is a very important gain. The other gain, that of increasing the possible distance of transmission or decreasing the energy required for a given distance—which is the same thing—is likewise important, but to utilize this effect requires that advantage be taken of the prolonged train of waves sent out; in other words, the receiving devices must be such as to allow a comparatively long series of waves to set a comparatively large amount of energy into motion, which then actuates the recording apparatus. To accomplish this it is necessary that the receiving circuits be arranged so as to be set in oscillation without much damping, and since most of the recording devices now employed have a large damping effect when connected to the receiving circuit, it is desirable that these should not be connected permanently, and only after the receiving circuit has been set into oscillation. A method of accomplishing this has also been devised by Poulsen, which thus enables him to reap the benefits of his wave generator. The arrangement is simple enough, as it consists merely in making an intermittent connection between the signalling device, such as a telephone receiver, and the oscillating circuit. This can be done by a revolving star wheel or in a number of ways. The effect is to leave the oscillating circuit free to oscillate undamped, except during

the periodic closing of the telephone circuit, at which time energy which has been set into oscillation by a comparatively long train of waves is turned into the telephone receiver to produce a click. These clicks succeed one another at a frequency which, of course, depends upon the number of contacts, and produce a note of corresponding pitch.

Poulsen thus seems to have contributed two important devices to the art of radio-telegraphy. He has developed a generator of undamped electrical waves and has devised a means of utilizing the energy of a train of waves. The results of a more extended experiment with this system will be awaited with considerable interest.—*Electrical Review.*

PROGRESS IN 1906. (By William Maver, Jr.).—With reference to wireless telegraphy also, it can not be said that there has been any very marked progress in the technical development of that art during the past year. Several interesting and novel detectors have been recently brought out, however, namely, the carborundum detector, due to Gen. Dunwoody, the De Forest audion, and the Pickard silicon detector.

The carborundum detector has been quite extensively employed in practice by the De Forest company and has proved to be commercially serviceable.

It is said to lack constancy of operation unless proper care is exercised in the selection of the crystals. In practice, a piece of carborundum about one cubic centimeter in size is clamped between two brass terminals or electrodes. Tests have shown this detector to be about as sensitive as the ordinary steel-carbon detector. It possesses the important advantages for shipboard use of durability and simplicity; also that its operation is not affected by jarring. It is practically interchangeable with the electrolytic detector as regards tuning.

The audion, which was recently described in these columns (*Electrical Review*, November 3, 1906), is based upon the Elster and Geitel tube arrangement for showing the ionization of a gas by means of an incandescent filament. To this arrangement De Forest adds a flux battery in an external circuit in which is placed a telephone receiver. In-coming electric oscillations apparently affect the equilibrium of the circuit and thus produce sounds in the telephone.

The Pickard silicon detector belongs to the thermo-electric class of receivers. The electrodes employed are pure silicon and a metallic element of low resistance. The energy of the receiver oscillations is converted into joulean heat at the element having high resistance and high thermo-electromotive force, which heat is converted at the contact into a short pulse of direct current in the telephone receiver.

Mr. Pickard has made numerous tests by means of specially devised apparatus to determine the sensitiveness of various detectors. (See *Electrical Review*, December 15, 1906). These tests show that the silicon detector is practically of the same order of sensitiveness as the electrolytic and magnetic detectors.

Another reported improvement in wireless telegraphy that may eventually lead to important results is the employment of undamped or persistent oscillations at the transmitting stations. Poulsen, the inventor of the telegraphone that bears his name, is accredited with having made notable advances in this direction by a modification of the Duddell singing arc. (*Electrical Review*, December 8, 1906.)

In Poulsen's device the positive electrode is copper, the negative electrode is carbon; the arc being produced in a closed box. The copper electrode is in the shape of a ring through which water is passed for cooling purposes. It is claimed that tests have demonstrated that by this method of setting up undamped oscillations, signalling greater distances with a much reduced expenditure of energy as compared with the spark method is obtainable.

It appears that the singing arc has already been employed in practice by the Telefunken company at their powerful station in Nauen, about 12 miles from Berlin. In this case, however, the arc is used in the ordinary atmosphere. The electrodes employed are copper and carbon. For cooling purposes the copper electrode is made in the shape of a cup filled with water and having a concave bottom, the carbon projecting into the cavity. The results of the experience with this type of oscillator at Nauen indicate that it will be difficult to maintain constant conditions at the arc, hence the frequency of the oscillations will be variable, a state of affairs which would be detrimental to sharply tuned systems. Another possible objection to this form of oscillator is that the energy output is comparatively small, much less than that obtainable with the spark. It remains to be seen whether greater uniformity of the oscillations, by permitting a better utilization of resonance at the receivers, will compensate for the lower energy output.

Still another method of obtaining undamped oscillations has been patented by S. G. Brown, London, England. This consists of a slowly moving metal disc, preferably aluminum, upon which a balanced block of copper loosely rests. This moving contact is shunted by an inductance and a capacity. When a direct current of 200 volts is passed through the moving contact, in series with a resistance and an inductance coil, exceedingly rapid oscillations of the order of over one million per second are set up in the condenser circuit shunting the moving contact. (See *Electrical Review*, December 15.)

This method of obtaining non-damped oscillations is to be employed in the Hozier-Brown Radio Telegraph Company.

Thus far but little progress has been made towards obtaining successful transmission of radio-telegraph signals in one direction only, and every wireless station continues to emit its electric radiations in all directions. During the past year Marconi and Braun have published the results of some experiments which they have made independently to confine the radiations of electric waves to one direction. Marconi's tests, which were described in the *Electrical Review*, May 26, 1906, were made with horizontal wires. He found that the maximum effects were obtained when the end of the horizontal wire connected with the receiver pointed towards the transmitting station.

Braun, in his experiments, proceeded on the theory that since electric waves are amenable to the same laws as light waves, it should be possible to direct electric waves by means of a parabolic reflector. But realizing the practical difficulties in the way of procuring a suitable reflector of this type it occurred to him that the same result might be reached by an arrangement of the transmitting wires whereby the intensity of the wave could be increased in one direction and decreased in another direction. To this end he constructed a station of three wooden masts arranged at the corners of an equilateral triangle, upon each of which masts a wire was erected, and from the lower point of which a connecting wire was carried to the transmitter. By setting up oscillations of equal phase in two of the wires and an oscillation of equal frequency, but which lagged or led in phase the oscillations of the other wires, interference between it and the other wires follows, and the equivalent of a shadow or an amplified wave in a given direction is thereby obtainable. (*Electrical Review*, September 16, 1905.)

The expected international conference on wireless telegraphy was held in Berlin last October and closed its sessions on Novmber 1. Many of the articles of the protocol covering the subjects to be considered by the conference were acted upon favorably. Among these is the article making it obligatory for coast stations and stations on shipboard to interchange telegrams regardless of the system of telegraphy employed. It was also decided that all stations are to be organized as far as possible to prevent in-

terference with other stations. The article providing that messages of distress shall have priority over all other messages was adopted unanimously. Action was taken also looking to the establishment of a bureau to which all matters pertaining to international wireless telegraphy shall be referred—similar to the international bureau governing land and cable telegraphs at Berne, Switzerland. The article proposed by the delegates representing the United States making it obligatory upon ships to interchange messages of whatever nature without regard to the type of apparatus employed on shipboard, was not accepted by Great Britain, Italy, Japan, Mexico, Persia, and Portugal.

Perhaps one of the most notable actions of the conference was the unanimous adoption of a term to designate more fittingly wireless telegraphy, namely radio-telegraphy. Hence future international conferences of this nature will be known as radio-telegraph conferences, and doubtless the term will be very generally adopted, inasmuch as it is a more appropriate term than wireless telegraphy, which from the first has been recognized as a misnomer.

We appear to be as far from the practical realization of trans-Atlantic radio-telegraphy to-day as was the case in 1901 when the consummation of this service within a few months was confidently predicted. Indeed the results of the long continued experiments recently conducted by Fessenden between Machrihanish, Scotland, and Brant Rock, Mass., so far as they have been published, indicate that the inherent difficulties of telegraphing continuously over very long distances are at present practically insurmountable.

For short distances, however, the expansion of radio-telegraphy has been very marked during the past year, and it is now almost impossible to accurately compute the number of wireless equipments in operation in all parts of the world. There are said to be 630 radio-telegraph plants of the Telefunken company, over 400 of the Marconi company and more than 180 of the De Forest company's sets in use in various parts of the world. There are besides in the aggregate many sets of the Lodge-Muirhead, the Fessenden, the Shoemaker, the Rochefort, the Stone, the Massie, and other wireless systems in operation. All of these wireless outfits, it may be noted, are, with only sufficient exceptions to prove the rule, for use on ships and on shore stations. In short, radio-telegraphy is rapidly filling the place which naturally belongs to it and which was assigned to it from its inception by all competent and disinterested persons, namely as a medium of communication between ship and ship and ship and shore.—*Electrical Review.*

MISCELLANEOUS.

THE PASSING OF SHIPS' BOATS.—With the new *Dreadnoughts* which are now being laid down at Portsmouth and Devonport, it is proposed making one of the most singular departures that has ever yet taken place in the annals of naval architecture. This is nothing less than the entire sweeping away of the greater number of the boats which have always lumbered up men-of-war, and which for many years past have fallen into almost complete desuetude. The many improvements and general progress which have taken place in modern shipbuilding, have made the battleships and cruisers of the present day practically unsinkable from any weather stress, through the buoyancy of their water-tight compartments, and it has therefore grown to be a recognized belief that all these lumbering boats are no longer required for life-saving purposes, any more than they are for the landing of military, who seldom, if ever, figure on battleships nowadays. The 60-foot picket boat is not to be discarded, as it is of great utility in torpedo attacks, having a speed of seventeen knots. Means for communication ashore being also necessary, the steam pinnace will be retained for

that purpose, but the great, cumbersome cutters are to be relegated to the auction-yard, and will, in a few years, become but a memory of the past. One of the factors which contributed to this step was an occurrence which took place during the war between Spain and the United States. When the Spanish fleet endeavored to force their way out of Santiago harbor with all their boats on board, the inflammability of the latter caused several ships to be set on fire, with such terrible consequences that Admiral Cervera declared that boats on deck were a death-trap to a warship going into action. Certainly they proved so to the unfortunate Spanish squadron.—*United Service Gazette.*

SUBMARINE SIGNALLING.—In our issue of September 1, 1905, we described in some detail the system of submarine signalling with which the Honorable Corporation of Trinity House experimented in the summer of that year, and published illustrations of the apparatus in use. The recent developments in the practical application of submarine sound transmission are due to American enterprise, and up to a few weeks ago the only light-house authorities who had installed submarine bells in connection with lightships under permanent service conditions were, so far as we know, those of the United States, Canada, and Germany. The Mersey Docks and Harbor Board have, however, recently fitted an apparatus of this description in connection with the Northwest light-vessel in the approach to the Mersey. The bell was put into service on December 24, and will, during thick or foggy weather, be sounded in groups of three strokes in quick succession every ten seconds. This permanent installation is the outcome of the experiments carried out by the board at intervals during the past 15 months.

We recently had an opportunity of witnessing the working of the bell signal receiving apparatus installed on board the *Campania*, and undoubtedly the additional aid to navigation provided by the Mersey Docks and Harbor Board will be welcomed by those responsible for the safety of vessels fitted with receiving mechanism plying between Liverpool and North American ports.

The submarine bell installations fitted to light-vessels on the Atlantic coast of the United States have, until recently, been maintained experimentally by the Submarine Fog-signal Company, but on November 30 last the light-house establishment took over the installations at the Boston, Nantucket Shoals, Fire Island, and Sandy Hook light-vessels, and in future will maintain and work them. The installations on five other vessels—viz., those off Fenwick Island, Winter Quarter Shoals, Cape Charles, Tail of the Horseshoe, and Diamond Shoals—are still maintained experimentally by the company. This action on the part of the lighthouse board would seem to indicate that, in the opinion of the United States authorities, the system had passed out of the initial experimental stage, and may be relied upon as a practical success. It is noteworthy that neither the Trinity House nor the Irish Lights Board have yet made any permanent installation of the bells, although both boards have under their control several light-vessels regularly passed by trans-Atlantic steamers fitted with receiving apparatus.

A correspondence between the Trinity House and the Zeeland Steamship Company has just been published, from which it appears that the latter has offered to install an apparatus for submarine signalling on board the Tongue lightship at the mouth of the Thames free of cost, and to bear all expenses for managing the apparatus until it is either taken over by the Trinity House or removed from service. The Netherlands government are stated to have made arrangements to supply submarine bells to the light-vessels on the Dutch coast, and the Queenborough and Flushing boats of the Zeeland Company are about to be fitted with receiving apparatus.

We understand that the subject will be discussed at the annual confer-

ence of the three lighthouse boards of the United Kingdom and the advisory committee on lighthouse works, to be held at the Board of Trade on January 30.

On the other hand, the Admiralty have been, and are, making exhaustive experiments, and trials have recently been carried out on H. M. S. *Antrim*, in conjunction with an attendant gunboat, with the view of testing the suitability of the system as a means of communication between ships.—*Engineer.*

SUBMARINE SIGNALLING.—Capt. W. W. Smith, superintendent of the Pittsburg Steamship Co., and Capts. George F. Parks and Samuel C. Allen have returned from their eastern trip filled with enthusiasm for the system of submarine signalling put out by the Submarine Signal Co., of 88 Broad street, Boston, Mass., which they inspected on the Atlantic coast. Capt. Parks was much impressed with the absolute precision of the signal system. In fact, while Capt. Parks was at the indicator box on board the steamship *H. F. Dimick*, of the Metropolitan line, and was picking up the bell of the Vineyard Sound lightship on the port bow, the course of the steamer was changed without his knowledge. Capt. Parks instantly picked up the bell on the starboard bow and was much surprised by this exhibition of the certainty with which the location could be determined.—*Nautical Gazette.*

CASUALTIES OF THE RUSSO-JAPANESE WAR.—The Russian General Staff has lately published the following casualty lists for the late war. Among the officers the losses were as follows: In Manchuria, killed, 709; wounded, 4073; missing, 251; prisoners, 304; died of disease, only 47, and died of wounds, 155. Of the Port Arthur garrison 722 officers only became casualties, distributed as follows: Killed, 139; wounded, 179; missing, 13; prisoners, 322; died of disease, 17; died of wounds, 52; the total casualties of all kinds therefore amongst officers amounted to 6261. Of the men—sergeants, rank-and-file—31,187 were killed, 115,885 were wounded, the enormous number of 37,493 are returned as missing, and 53,987 were taken prisoners, making the total casualties among the men 238,462. In the Port Arthur garrison alone there were 10,000 men killed, and 27,557 prisoners, and in Saghalien there were 1500 casualties. The losses in the navy, in the frontier guards, and in the troops employed in safeguarding the railway are not included in the above numbers.

According to the returns of the Minister of War at Tokio, the casualties in the Japanese army were as follows: Killed, 47,152; died of wounds, 11,424; died of sickness or disease, 21,802; total, 80,378. This total is thus subdivided: Officers, 2113; non-commissioned officers and soldiers, 76,908; non-combatants, 1357. Without counting the last-mentioned, the losses per different arm were as follows: Military police, 64; infantry, 64,405; cavalry, 829; artillery, 3957; engineers, 1944; army service corps, 8130; staff 81; doctors and sanitary staff, 517; veterinary department, 11; musicians, 3. The heavy losses of the infantry and the army service corps show that the transport was constantly pushed up to the front in a country that offered opportunities to infantry, and to the exceptional use of that arm in the siege of Port Arthur. *La France Militaire* is informed that there were 153,673 Japanese soldiers wounded in action, and 16,456 men wounded by accidents; total of these, 170,129. Only 11,424, or scarcely 7 per cent died. The total number of sick was 221,136, of whom 203,270 suffered from non-contagious, and 17,866 from contagious disease. Of these 10 per cent died. The result is to a great extent due to the incessant care given to all measures of hygiene in the Japanese army, and to the personal cleanliness of the Japanese.

From a statement made by Surgeon General Koike at the recent medical congress in Tokio it appears that in the war of 1894-95 the proportion of

sick to every man wounded was 6.93, while to every man who died of wounds 12.09 died of disease. In the campaign of 1900 these proportions fell to 4.37 and 1.97, and there was a wonderful diminution in the recent war to the proportions of 1.15 and 0.37. The percentages of sick in the three successive campaigns were respectively 59.20, 34.88, and 36.04, while the deaths from sickness were 9.29, 4.33 and 2.99. Every man carried with him in Manchuria a little "Guide to Sanitation on Campaign," and at every opportunity he was personally instructed. Moreover, he carried certain tablets or pills as prophylactics. Water was boiled whenever this could be done, and locomotive boilers accompanied the troops, but otherwise a filter of special character was employed.—*Army and Navy Journal.*

THE POSITION OF THE SUBMARINE.—The building of very big warships enhances the value of very little warships; and that brings to the fore the policy of constructing submarines. If a small, cheap boat, like a submarine, stands as good a chance of bagging a two-million-pound *Dreadnought* as she does of exterminating a one-million-pound *Majestic*, then the efficiency of the small boat is distinctly advanced. So much being evident, the question remains, What is the chance? That it is considered to be an increasing one may be gathered from the fact that every first-class power is devoting greater attention to the acquisition of a satisfactory design of submarine boat; and shows more readiness to provide money for the building of such craft. It is therefore opportune to consider the whole question in connection with the details of the past year's work in our own navy given in another article in this issue, and of the great advance lately attained, as a consequence of research work, in propelling machinery for submarine use. We have in commission, or in course of construction, over 40 submarines; but in view of the activity of foreign powers it is more and more to be regretted that our Admiralty reduced the number to be laid down during the current financial year from 12 to 8, and the facts since disclosed strengthen the objection to this course which we expressed at the time.

Our chief rival in the possession of weapons for submarine warfare is France. The French government were ahead of us in adding submarine boats to the navy of the Republic, and now holds the superior position so far as numbers are concerned. According to an Admiralty return, France had 39 submarine boats completed last spring—as against our 25—and 50 building or projected, as against our 23. Some of the French boats appear, on paper at any rate, far more powerful than our own. Thus the French had 18 boats in construction, of a displacement of 391 tons, each fitted with no less than seven torpedo tubes; whilst there were six others under construction, each of 383 tons, and having six torpedo tubes. Our own boats of the *C* class, of which there are 11 building, are of 313 tons, and have but two tubes each, although they each carry four torpedoes. There is every probability, however, of a considerable increase in the size and power of the new British boats.

The British fleet of submarine boats has, however, the great advantage of being composed of homogeneous groups, whilst the French vessels are a very mixed collection. How far this would affect tactics in this entirely new field of warfare it is difficult to say, but it is probable that it would have a considerable influence. The original idea of operation with the submarine boat was that a single one would creep out and catch the battleship or big cruiser unawares. The same theory was held when the torpedo-boat first came to the fore, but it was speedily found to be ill-founded; both maneuvers and the small amount of war experience that has accrued having shown that attack in group is the proper maneuver. Of course, if the torpedo-boat could make reasonably sure of surprise, and of the trustworthiness of its weapon, the single-unit attack would be the most profitable; but concealment until within torpedo range is by no means to be depended upon; and thus when attacking in groups a second or third

may get its blow home while attention is being devoted to one or two others.

With the submarine the details are different, but the ultimate principle is much the same. The submarine has a means of concealment denied to the torpedo-boat, but she is very much slower, and when she takes advantage of her means of concealment, by submergence, she cripples her power of attack enormously in some respects. It may be concluded that no belligerent vessels during any future war will lie at anchor, unless in a well-protected harbor, or in waters so far distant as to preclude the possibility of submarine attack; we have, therefore, only to consider maneuvers under steam. An American naval officer, who has made submarine vessels a study, has said that "the submarine, *when within torpedo range* is superior to the battleship, since the battleship is vulnerable to the torpedo—the weapon of the submarine." This writer, Lieutenant Halligan, does well to emphasize the words he puts in italics; but even when within torpedo range the submarine has not victory assured. Torpedoes fired from a submarine do not always hit their mark, although the application of the gyroscope has done wonders in adding to their trustworthiness. A British boat having four torpedoes on board, or a French boat with seven tubes—we are not aware how many torpedoes the latter vessels carry—might have a further chance; but unless the torpedo were to be fired at random, the boat would have to come to the surface again to sight for a second shot, supposing the ship had not, in the meantime, steamed out of range.

In order to make an effective attack upon a ship under way, it is necessary that the submarine boat should intercept the vessel in her course. The legend surface speed of the *C* class of British submarines is 13 knots, and their submerged speed for 3 hours is put down at 8½ knots. These are really remarkable rates of traveling for vessels handicapped in the manner submarine boats necessarily are, but it is anticipated that the *D* class will make 15 or 16 knots on the surface and 9 knots submerged. Some of the forthcoming French boats have been assigned 13 knots and 8 knots respectively for surface and submerged speeds, whilst the two most recently projected vessels are intended to have 15 knots and 8 knots; but the designs are not yet complete.

We will suppose, however, that a submarine boat has reached the 14-knot and 9-knot standard. If the boat were to sight a hostile ship approaching directly towards her at 16 knots when at a distance of 4 miles, it would take a quarter of an hour for the ship to reach the submarine, supposing the latter to be stationary. That would be a piece of great good luck for the submarine, and, though it might occur, the probability is hardly great enough for it to be depended upon. We will suppose, however, that, in place of the boat being right in the enemy's path, the ship is steaming on a course that would pass the position occupied by the submarine at the time of sighting at a distance of 2 miles, the distance at which the ship was discovered being again 4 miles. The submarine would have her enemy as she sighted her 30 degrees before the beam. To take a simple case: if the boat, traveling at 9 knots, made directly for the course the ship was pursuing, it would take her rather more than 13 minutes to do the 2 miles which would bring her to a point cutting the ship's course, or, say, nearly 13 minutes to come within torpedo range. In the meantime the ship would have been occupying about the same time to cover the 3½ miles that would lie between her first sighted position and the point where the two would meet. Under these circumstances, the submarine would be within striking distance, and able to fire one torpedo.

The tactics are not necessarily those that would be pursued, but the original conditions supposed are favorable to the boat; that is to say, the luck would be in her favor. No time has been allowed for her filling her tanks to assume the submerged position, and she is supposed to have maintained a direct course. What part of the run would be made under water

would be a matter for the discretion of the commander, who would be governed by the light and the conditions of weather; but it would be wise to keep the conning-tower above the surface as long as possible, because it is difficult to keep an object in sight by the periscope, and also extremely difficult to judge distance. The conning-tower awash, however, makes the position of the boat visible by the wave it creates—a more noticeable thing than the tower itself in some states of the sea and atmosphere, when the boat is traveling at high speed.

In ordinary daylight the ship would be seen by the submarine at a greater distance than eight miles, but it must be remembered that, even when the boat is highest out of water, the deck is elevated only a few inches above the surface. Standing on the top of the conning-tower, a man would have a horizon distance of not much more than 3½ miles, whilst a height of 50 feet gives only slightly over an 8-mile radius. In daylight, however, there would be a greater chance of the submarine being sighted; and in that case the ship would alter her course so as to avoid the slow-moving submarine; for at present it is doubtful whether any effective means have been devised for a counter-attack on these boats when they are below the surface. The most promising suggestion has been the use of small torpedoes with light charges, sufficient, however, to fatally damage so vulnerable a structure as a submarine boat. As they would deal with slow craft, these torpedoes need not be so fast as those used for swifter ships. They could be carried by boats and easily handled. Of course, there is the chance of going over, as well as under, the submarine, even if her position were known; but the torpedoes would be comparatively cheap, so that a fair number might be expended; and if the submarine had been sighted and were known to be attacking the ship, her position could be very fairly estimated, as her lack of speed does not give her much choice. The value of torpedo-boats, destroyers, and pinnaces to act as vedettes for discovering submarines and attacking them with quick-firing guns, or with light torpedoes, will be understood. Even if the small craft could not injure the submarines, they might prevent them from coming up to take observations, and thus frustrate their object.

The improvements in the design, and consequent advance in efficiency, of the submarine boat has been a remarkable feature of recent naval history. The various naval authorities concerned have, however, so well kept their secrets that there is not much to say on the subject. At the meeting of the American Society of Naval Architects and Marine Engineers, held in New York last month, an instructive paper on "The Development of Submarines" was read by Mr. L. Y. Spear, a member of that society. In this paper are given some interesting particulars of a trial of the submarine *Fulton*, as carried out by the United States Navy Department last June. The *Fulton* was of the *Adder* class, but has been somewhat altered and much improved in detail since she was built. The *Adder* is a single-screw boat, with the usual gasoline and electric means of propulsion. She is 64 feet long by 11 feet 9 inches beam, and displaces submerged 122 tons.

The program was for the *Fulton* to leave Newport harbor and proceed at full speed in the light condition to a stake-boat anchored in the open sea. She was there to submerge and find a target 10 nautical miles distant to seaward. This target consisted of two ships' cutters 300 feet apart, and marked by a yacht 250 yards west of the target. All observations during this attack were to be made by the periscope. As it was feared torpedoes might be lost, the *Fulton* was simply required to expose her periscope within torpedo range, and then, submerging the periscope, to pass through the target. She was then to return submerged and pass round a stake-boat three miles distant and again attack the target, this time making observations from the conning-tower only, the eye-piece of the periscope being removed. She was then to return submerged over the course, pass to the light condition, and proceed under her main engines, charging batteries

while under way. After charging batteries she was to remain submerged for 12 hours. The whole trial was to continue for at least 24 consecutive hours, during which the vessel and crew were to be entirely self-sustaining.

These were the conditions laid down, and the *Fulton* more than fulfilled them. She was submerged 15½ hours out of the 24; during the remaining 8½ hours she was cruising on the surface. During the 12 hours' continuous submergence the full crew and one observer were on board, and no fresh air was supplied until the end of the test. The average depth maintained during the attack was 20 feet, which was sufficient to entirely submerge the periscope. During the 10-mile run to the target the periscope was momentarily exposed at intervals of about two miles, the boats, on account of their small elevation, were difficult to pick up. The final observation was made at a distance of 825 yards from the target.

These particulars of an interesting trial give a very fair account of what a submarine boat can accomplish. How the trials of our own craft would compare with the run of the *Fulton* we have no means of knowing. There is little doubt, however, that the submarines of the royal navy are second to none, and are probably in advance of all others.—*Engineering.*

EXTRACTS FROM "THE ORGANIZATION OF A MODERN FLEET FOR WAR; CONDUCT IN ACTION, ETC., ETC."

BY REAR-ADMIRAL SIR CHARLES CAMPBELL, K. C. M. G., C. B., D. S. O.

The one aim and object of all spotting is to get an instantaneous communication from the spotter to the sight setter. It needs little or no demonstration to accentuate the necessity for rapidity! Was the last projectile a hit? How much over or short or to right or left? And how soon can the sight setter know the plunge position?

The unfortunate predicament in which we are placed by the present system is that it requires an elaborate bag of tricks in the shape of conduct wires and instruments which must be placed in the most probable path of the adversaries' projectiles, and whose principal necessity is height above deck.

I hope and believe that it will be possible before long to do away with the funnels. At present the two most probable solutions of the problem of dispensing with funnels seem to lay between a system of utilizing the wasted energies of coal to obtain power, and a system of propulsion without fires, substituting in the latter case explosive force, as already used in motor cars and boats under the name of internal combustion. Of one thing we may be certain, and that is, that the funnels are quite as sinful to-day as the sails were twenty years ago, and their removal is vitally important. The absence of boilers, funnels, and coal would greatly assist the much-needed reduction of complement in a fleet-ship, both in officers and men, and it would be another instance of the irony of fate if the present controversies on education, rank and position ended in effacement.

In 1887 I was criticised by a talented officer then commanding afloat for treating the turbine engine as an accepted form of propulsion. He stated in the discussion: "At all events, it has not proved itself hitherto a factor on which we can rely, and therefore the lecturer has drawn, to a certain extent, on what he thinks may be possible in the future, rather than what is possible in the present." Now that is what I conceive is the duty of every lecturer who is asked to read a paper on a given subject in this theater. Study historical retrospect and watch closely the trend of the inventions of home and foreign genius; bring the line up to date, and then endeavor to forecast the direction of future improvement. That, to my mind, spells progress. As you cannot obtain one glimpse of the future

except through the medium of a reflected past, study the past; then predict, and act on your predictions. That is the duty of those entrusted with the fearful responsibility for the safety of these little islands and their big dependencies. All I wish to predict to-day is, that "internal-combustion engines," oil, gas, or chemical, will grow in size and number, and will eventually become the motive power for the purposes of commerce and war, and that in the long run, air fleets will be a serious menace to "water fleets," and may eventually replace them. I was just as certain in 1887 that the "turbine" was the engine of the future in large vessels for war or trade as I am to-day that "internal-combustion engines" will gradually be used by ships of ever-increasing tonnage; that masts and funnels must go for good and all; and that aëroplanes and navigable air-ships for war and traveling are surely attaining a position which entitles them to serious consideration.

I wish to place a wide gulf between the composition of a division, squadron, or fleet, and its tactical formation for battle.

The first should be definitely laid down and prepared long before hand, is probably now prepared. But to the admiral in command must be left the manipulation of the force for which he is responsible to the country. In 1887 I stated: "We have yet to learn the most suitable and successful formation for attack and defence," and I advocated "perfection in all systems, and rapid changes from one formation to another."

Gun power and accuracy have again come to the rescue. The single line ahead has been proved and accepted by all to be the one possibility of a successful fleet action. Wheeling for a necessary change of direction, and altering course together when necessary, to take ground to the right or left. The single line has, in addition to its effectiveness for concentration of gun fire, the advantage of being the most simple and easiest kept of all formations, and requires the minimum of signals.

I now state without fear of contradiction that there is no known formation which the opponent could possibly take up, that would not place him at an overwhelming disadvantage when pitted against the single line ahead.

Therefore, it is clear to my mind that all systems of groups, pairs, double columns, bow and quarter lines, and other formations, some of which I have advocated in days gone by, are obsolete and useless. And why? Again, I say, owing to the overwhelming supremacy of accurate heavy gun fire.

All that it is now necessary to master is the art of following your leader in single line ahead without signals, taking ground to the right or left, by order, when an increase or decrease of range becomes advantageous—some simple form of altering course sixteen points together, completes all that can be required.

Practice in peace what you would have to do in war. We know that the result of a fleet action will entirely depend on the ammunition expended doing a relative amount of damage. Tries are of no value, and it is only goals that count in this game.

Practice is the one and only means of attaining perfection. There is no such clear proof of the result of practice as in "out-and-in net defence." In 1886 fifty minutes was considered a smart time; in 1906 fifty seconds is considered fairly smart.

At least once a year, and for a period of not less than a month, the whole station force, or in case of the Atlantic, home, and reserve, the combined force, should muster and go to sea complete for war and carry out battle practice, one fleet against the other. During this time the manœuvers cannot be too real, and even risks must be run in order to insure high tactical training and skill, and all filling up of ammunition, fuel, and stores should take place at sea.—*Royal United Service Institution.*

THE ART OF CUTTING METALS.[1] (By Fred W. Taylor).—The experiments described in this paper were undertaken to obtain a part of the information necessary to establish in a machine shop our system of management, the central idea of which is: (A) To give each workman each day in advance a definite task, with detailed written instructions, and an exact time allowance for each element of the work. (B) To pay extraordinarily high wages to those who perform their tasks in the allotted time, and ordinary wages to those who take more than their time allowance. There are three questions which must be answered each day in every machine shop by every machinist who is running a metal cutting machine, such as a lathe, planer, drill press, milling machine, etc., namely:

a. What tool shall I use?
b. What cutting speed shall I use?
c. What feed shall I use?

Our investigations, which were started 26 years ago with the definite purpose of finding the true answers to these questions under all the varying conditions of machine shop practice, have been carried on up to the present time with this as the main object still in view.

ROUGHING WORK EXCLUSIVELY CONSIDERED.

The writer will confine himself almost exclusively to an attempted solution of this problem as it affects "roughing work"; *i. e.*, the preparation of the forgings or casting for the final finishing cut, which is taken only in those cases where great accuracy or high finish is called for. Fine finishing cuts will not be dealt with. Our principal object will be to describe the fundamental laws and principles which will enable us to do "roughing work" in the shortest time, whether the cuts are light or heavy, whether the work is rigid or elastic and whether the machine tools are light and of small driving power, or heavy and rigid with ample driving power. In other words, our problem is to take the work and machines as we find them in a machine shop and by properly changing the countershaft speeds, equipping the shop with tools of the best quality and shapes and then making a slide rule for each machine to enable an intelligent mechanic with the aid of these slide rules to tell each workman how to do each piece of work in the quickest time.

It may seem strange to say that a slide rule enables a good mechanic to double the output of a machine which has been run, for example, for 10 years by a first-class machinist having exceptional knowledge of and experience with his machine and who has been using his best judgment. Yet our observation shows that, on the average, this understates the fact. To make the reason for this more clear it should be understood that the man with the aid of his slide rule is called upon to determine the effect which each of the 12 elements or variables given below has upon the choice of cutting speed and feed; and it will be evident that the mechanic, expert or mathematician does not live who, without the aid of a slide rule or its equivalent, can hold in his head these 12 variables and measure their joint effect upon the problem. These 12 elements or variables are as follows:

a. The quality of the metal which is to be cut.
b. The diameter of the work.
c. The depth of the cut.
d. The thickness of the shaving.
e. The elasticity of the work and of the tool.
f. The shape or contour of the cutting edge of the tool, together with its clearance and lip angles.

---

[1] Extracts from Part I of the president's annual address at the New York meeting (December, 1906) of the American Society of Mechanical Engineers.

g. The chemical composition of the steel from which the tool is made, and the heat treatment of the tool.

h. Whether a copious stream of water, or other cooling medium, is used on the tool.

j. The duration of the cut—*i. e.*, the time which a tool must last under pressure of the shaving without being reground.

k. The pressure of the chip or shaving upon the tool.

l. The changes of speed and feed possible in the lathe.

m. The pulling and feeding power of the lathe.

Broadly speaking, the problem of studying the effect of each of the above variables upon the cutting speed and of making this study practically useful may be divided into four sections, as follows:

(A) The determination by a series of experiments of the important facts or laws connected with the art of cutting metals.

(B) The finding of mathematical expressions for these laws which are so simple as to be suited to daily use.

(C) The investigation of the limitations and possibilities of metal cutting machines.

(D) The development of an instrument (a slide rule) which embodies, on the one hand, the laws of cutting metals, and on the other the possibilities and limitations of the particular lathe or planer, etc., to which it applies, and which can be used by a machinist without mathematical training to quickly indicate in each case the speed and feed which will do the work quickest and best.

THE EXPERIMENTS BEGUN IN 1880.

In the fall of 1880 the machinists in the small machine shop of the Midvale Steel Company, Philadelphia, most of whom were working on piecework in machining locomotive tires, car axles, and miscellaneous forgings, had combined to do only a certain number of pieces per day on each type of work. The writer, who was the newly appointed foreman of the shop, realized that it was possible for the men to do in all cases much more work per day than they were accomplishing. He found, however, that his efforts to get the men to increase the output were blocked by the fact that his knowledge of just what combination of depth of cut, feed and cutting speed would in each case do the work in the shortest time was much less accurate than that of the machinists who were combined against him. His conviction that the men were not doing half as much as they should do, however, was so strong that he obtained the permission of the management to make a series of experiments to investigate the laws of cutting metals, with a view to obtaining a knowledge at least equal to that of the combined machinists who were under him. He expected that these experiments would last not longer than six months. With the exception of a few comparatively short periods, however, these experiments have continued until the present time, through a term of about 26 years.

The writer wishes to call attention to the fact that in these first experiments he was far more fortunate than almost all of the experimenters who have investigated the subject since then, in having at his disposal a comparatively large mass of uniform metal to work upon, and a comparatively large and powerful machine to work with, a 66-inch diameter boring mill and large locomotive tires made of hard tire steel of uniform quality having been used. He was also especially fortunate in having over him as president of the company William Sellers, who, as is well known, was one of the most patient and broad-minded experimenters of his day. Mr. Sellers, in spite of the protests which were made against the continuation of this work, allowed the experiments to proceed, even, at first, at a very considerable inconvenience and loss to the shop.

The extent of this inconvenience will be appreciated when it is under-

stood that we were using a 66-inch diameter vertical boring mill, belt driven by the usual cone pulleys, and that in order to regulate the exact cutting speed of the tool it was necessary to slow down the speed of the engine that drove all of the shafting in the shop, a special adjustable engine governor having been bought for this purpose. For over two years the whole shop was inconvenienced in this way, by having the speed of its main line of shafting greatly varied, not only from day to day but from hour to hour. Before the two years had elapsed, however, the writer had obtained such valuable and unexpected results from the experiments as to much more than justify all of the annoyance and expenditure, and soon after that he readily obtained permission to employ a young technical graduate to devote his whole time to the continuation of this work.

ACKNOWLEDGMENTS TO THOSE WHO ASSISTED IN THE WORK.

G. M. Sinclair, a graduate of Stevens Institute of Technology, devoted his entire time to this work from 1884 to 1887, when he left the employ of the company. H. L. Gantt, also a graduate of Stevens Institute, succeeded Mr. Sinclair in July, 1887, and has been interested with us in carrying on these experiments throughout their whole period. In 1898 Maunsel White, of Bethlehem, another graduate of Stevens Institute, joined us and has been actively interested in our work up to this time. Carl G. Barth, a graduate of the Technical School of Horten, Norway, joined us in 1899, and is still actively working on our investigations.

During these years we have consulted so freely together in all matters relating to these experiments that with few exceptions hardly a step has been taken which can be said to have originated with any one man. Therefore, whatever credit or blame may come to this work should be impartially divided among us. In writing this paper, then, no effort will be made to discriminate, as to the results which have been obtained in our investigations, between the work of one man and another.

Our experiments were continued in the works of the Midvale Steel Company until 1889, when the writer left its employ. Since then these investigations have been carried on in various shops and at the expense of different companies. Among these we would especially acknowledge our indebtedness to the Cramp's Shipbuilding Company, Wm. Sellers & Co., the Link-Belt Engineering Company, Dodge & Day. and, more than all, to the Bethlehem Steel Company.

In carrying on this work more than 10 machines have been fitted up at various times with special driving apparatus and the other needed appliances, all machines used since 1894 having been equipped with electric drives, so as to obtain any desired cutting speed. The thoroughness with which the work has been done may perhaps be better appreciated when it is understood that we have made between 30,000 and 50,000 recorded experiments, and many others of which no record was kept. In studying these laws we have cut up into chips with our experimental tools more than 800,000 pounds of steel and iron. More than 16,000 experiments were recorded in the Bethlehem Steel Company. We estimate that up to date between $150,000 and $200,000 have been spent upon this work, and it is a very great satisfaction to feel that those whose generosity has enabled us to carry on the experiments have received ample return for their money through the increased output and the economy in running their shops which have resulted from our experiments.

SECRETS GUARDED 26 YEARS NOW REVEALED.

Throughout the whole 26 years we have succeeded in keeping almost all of these laws secret, and in fact since 1889 this has been our means of obtaining the money needed to carry on the work. We have never sold any information connected with this art for cash, but we have given to one company after another all of the data and conclusions arrived at through

our experiments in consideration for the opportunity of still further continuing our work. In one shop after another machines have been fitted up for our use, workmen furnished us to run them, and especially prepared tools, forgings and castings supplied in exchange for the data which we had obtained to date; and we have the best indication that they received full value for the money spent from the fact that the same company fitted up for us at intervals of several years three sets of apparatus, the additional knowledge obtained each time evidently warranting them in making the added outlay.

During this period all of the companies who were given this information and all of the men who worked upon the experiments, were bound by promises to the writer not to give any of this information away nor to allow it to be published. Most of these promises were verbal; and in this day, when there is so much talk about dishonesty and graft in connection with some of our corporations and prominent business men, it is a notable fact that through a period of 26 years it has not come to our knowledge that any one of the many men or companies connected with this work has broken a promise. The writer has his doubts whether any other country can produce a parallel record of such widespread good faith among its engineers and mechanics.

It seems to us that the time has now come for the engineering fraternity to have the results of our work, in spite of the fact that this will cut off our former means of financing the experiments. However, we are in hopes that the money required to complete this work may be obtained from some other source.

The writer has no doubt that many of the discoveries and conclusions which mark the progress of this work have been and are well known to other engineers, and we do not record them with any certainty that we were the first to discover or formulate them, but merely to indicate some of the landmarks in the development of our own experiments, which to us were new and of value. The following is a record of some of our more important steps:

CHRONOLOGY OF DISCOVERIES.

A. In 1881, the discovery that a round nosed tool could be run under given conditions at a much higher cutting speed and therefore turn out much more work than the old-fashioned diamond pointed tool.

B. In 1881, the demonstration that, broadly speaking, the use of coarse feeds accompanied by their necessarily slow cutting speeds would do more work than fine feeds with their accompanying high speeds.

C. In 1883, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from the steel forging by the tool, would permit an increase in cutting speed, and, therefore, in the amount of work done of from 30 to 40 per cent. In 1884, a new machine shop was built for the Midvale Steel Works, in the construction of which this discovery played a most important part; each machine being set in a wrought iron pan in which was collected the water (supersaturated with carbonate of soda to prevent rusting), which was thrown in a heavy stream upon the tool for the purpose of cooling it. The water from each of these pans was carried through suitable drain pipes beneath the floor to a central well from which it was pumped to an overhead tank from which a system of supply pipes led to each machine. Up to that time the use of water for cooling tools was confined to small cans or tanks from which only a minute stream was allowed to trickle upon the tool and the work, more for the purpose of obtaining a water finish on the work than with the object of cooling the tool; and, in fact, these small streams of water are utterly inadequate for the latter purpose. So far as the writer knows, in spite of the fact that the shops of the Midvale Steel Works until recently have been open to the public since 1884, no other shop in this

country was similarly fitted up until that of the Bethlehem Steel Company in 1899, with the one exception of a small steel works which was an offshoot in personnel from the Midvale Steel Company.

D. In 1883, the completion of a set of experiments with round nosed tools; first, with varying thicknesses of feed when the depth of the cut was maintained constant; and, second, with varying depths of cut while the feed remained constant, to determine the effect of these two elements on the cutting speed.

E. In 1883, the demonstration of the fact that the longer a tool is called upon to work continuously under pressure of a shaving, the slower must be the cutting speed, and the exact determination of the effect of the duration of the cut upon the cutting speed.

F. In 1883, the development of formulæ which gave mathematical expression to the two broad laws above referred to. Fortunately these formulæ were of the type capable of logarithmic expression and therefore suited to the gradual mathematical development extending through a long period of years, which resulted in making our slide rules and solved the whole problem in 1901.

G. In 1883, the experimental determination of the pressure upon the tool required on steel tires to remove cuts of varying depths and thickness of shaving.

H. In 1883, the starting of a set of experiments on belting described in a paper published in *Transactions* Vol. 15 (1894).

J. In 1883, the measurement of the power required to feed a round nosed tool with varying depths of cut and thickness of shaving when cutting a steel tire. This experiment showed that a very dull tool required as much pressure to feed it as to drive the cut. This was one of the most important discoveries made by us, and as a result all steel cutting machines purchased since that time by the Midvale Steel Company have been supplied with feeding power equal to their driving power and very greatly in excess of that used on standard machine tools.

K. In 1884, the design of an automatic grinder for grinding tools in lots and the construction of a toolroom for storing and issuing tools ready ground to the men.

L. From 1885 to 1889, the making of a series of practical tables for a number of machines in the shops of the Midvale Steel Company, by the aid of which it was possible to give definite tasks each day to the machinists who were running machines, and which resulted in a great increase in their output.

M. In 1886, the demonstration that the thickness of the chip or layer of metal removed by the tool has a much greater effect upon the cutting speed than any other element, and the practical use of this knowledge in making and putting into everyday use in our shops a series of broad nosed cutting tools which enabled us to run with a coarse feed at as high a speed as has been before attained with round nosed tools when using a fine feed, thus substituting, for a considerable portion of the work, coarse feeds and high speeds for our old maxim of coarse feeds and slow speeds.

N. In 1894 and 1895, the discovery that a greater proportional gain could be made in cutting soft metals through the use of tools made from self-hardening steels than in cutting hard metals, the gain made by the use of self-hardening tools over tempered tools in cutting soft cast iron being almost 90 per cent, whereas the gain in cutting hard steels or hard cast iron was only about 45 per cent. Up to this time the use of Mushet and other self-hardening tools had been almost exclusively confined to cutting hard metals, a few tools made of Mushet steel being kept on hand in every shop for special use on hard castings or forgings which could not be cut by the tempered tools. This experiment resulted in substituting self-hardening tools for tempered tools for all "roughing work" throughout the machine shop.

P. In 1894 and 1895, the discovery that in cutting wrought iron or steel a heavy stream of water thrown upon the shaving at the nose of the tool produced a gain in cutting speed of self-hardening tools of about 33 per cent. Up to this time the makers of self-hardening steel had warned users never to use water on the tools.

Q. From 1898 to 1900, the discovery and development of the Taylor-White process of treating tools; namely, the discovery that tools made from chromium-tungsten steels when heated to the melting point would do from two to four times as much work as other tools.

R. In 1899-1902, the development of our slide rules, which are so simple that they enable an ordinary workman to make practical and rapid every-day use in the shop of all the laws and formulæ deduced from our experiments.

S. In 1906, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from cast iron by the tool would permit an increase in cutting speed, and therefore in the amount of work done, of 16 per cent.

T. In 1906, the discovery that by adding a small quantity of vanadium to tool steel to be used for making modern high speed chromium-tungsten tools heated to near the melting point, the hardness and endurance of tools, as well as their cutting speeds, are materially improved.

THE GAIN FROM THE SLIDE RULE GREATEST OF ALL.

While many of the results of these experiments are both interesting and valuable, we regard as of by far the greatest value that portion of our experiments and of our mathematical work which has resulted in the development of the slide rules—*i. e.*, the patient investigation and mathematical expression of the exact effect upon the cutting speed of such elements, as the shape of the cutting edge of the tool, the thickness of the shaving, the depth of the cut, the quality of the metal being cut and the duration of the cut, etc. This work enables us to fix a daily task with a definite time allowance for each workman who is running a machine tool, and to pay the men a bonus for rapid work.

The gain from these slide rules is far greater than that of all the other improvements combined, because it accomplishes the original object for which in 1880 the experiments were started—*i. e.* that of taking the control of the machine shop out of the hands of the many workmen and placing it completely in the hands of the management, thus superseding "rule of thumb" by scientific control.

By far the most difficult and illusive portion of this work has been the mathematical side: First, finding simple formulæ which expressed with approximate accuracy the effect of each of the numerous variables upon the cutting speed, and, second, finding a rapid method of using these formulæ in the solution of the daily machine shop problems. Several times during the progress of this mathematical work the writer, feeling himself completely baffled, has asked the expert assistance of some of the best mathematicians in the country. They all smiled when told that we expected to solve mathematically a problem containing 12 variables, and in each case, after keeping the formulæ before them for a longer or shorter time, returned the problem to the writer with the statement that it belonged distinctly in the realm of "rule of thumb" or empiricism, and could be solved only by the slow method of trial and error.

TWO TYPES OF EXPERIMENTS.

In the investigation of an art such as that of cutting metals, and about which at the time our work was started there was so little scientific knowledge, two types of experiments are possible:

First, the thoroughly scientific type, in which, after an analysis of all

the variable elements which affect the final result, an attempt is made to hold all of the elements constant and uniform except the one variable which is under investigation, and this one is systematically changed and its effect upon the problem carefully noted. It is to this type that our experiments belong, thanks mainly to the fact that William Sellers (one of the most scientific experimenters of his day) was president of the Midvale Steel Company when the writer started his work.

Second, the type of experiments in which the effect of two or more variables upon the problem is investigated at the same time and in the same experiment. This method is of course much quicker than the thoroughly scientific type, and it is largely for this reason, in the opinion of the writer, that almost all of the other experimenters in this field have chosen it. Several of the experiments of this type have proved most valuable and developed much useful information, and it is with hesitancy that the writer criticises the work of any of these experimenters, since he appreciates most keenly the difficulties under which they worked, and is grateful for the information contributed by them to the art.

Almost the whole course of our experiments is marked by imperfections in our methods, which, as we have realized them, have led us to go again more carefully over the ground previously traveled. These errors may be divided into three principal classes: (A) The adoption of wrong or inadequate standards for measuring the effect of each of the variables upon the cutting speed. (B) Failure on our part from various causes to hold all of the variables constant except the one which was being systematically changed in order to study the effect of these changes upon the cutting speed. (C) The omission either through oversight or carelessness on our part of some one of the precautions which should be taken to insure accuracy, or failure to record some of the phenomena considered unimportant at the time, but which afterward proved to be essential to a complete understanding of the facts.

EFFECT OF EACH VARIABLE ON CUTTING SPEED.

The effect of each variable upon the problem is best determined by finding the exact rate of cutting speed (say, in feet per minute) which shall cause the tool to be completely ruined after having been run for 20 minutes under uniform conditions.

For example, if we wish to investigate the effect which a change in the thickness of the feed has upon the cutting speed it is necessary to make a number of tools which are in all respects uniform as to the exact shape of their cutting edge, their clearance and lip angles, their chemical composition and their heat treatment. These tools must then be run one after another, each for a period of 20 minutes, throughout which time the cutting speed is maintained exactly uniform. Each tool should be run at a little faster cutting speed than its predecessor, until that cutting speed has been found which will cause the tool to be completely ruined at the end of 20 minutes (with an allowance of a minute or two each side of the 20-minute mark). In this way that cutting speed is found which corresponds to the particular thickness of shaving which is under investigation.

A change is then made in the thickness of the shaving and another set of 20-minute runs is made, with a series of similar uniform tools, until the cutting speed corresponding to the new thickness of feed has been determined; and by continuing in this way all of the cutting speeds are found which correspond to the various changes of feed. In the meantime every precaution must be taken to maintain uniform all the other elements or variables which affect the cutting speed, such as the depth of the cut and the quality of the metal being cut; and the rate of the cutting speed must be frequently tested during each 20-minute run to be sure that it is uniform.

The cutting speeds corresponding to varying feeds are then plotted as points upon a curve, and a mathematical expression is found which represents the law of the effect of feed upon cutting speed. We believe that this standard or method of procedure constitutes the very foundation of successful investigation in this art, and it is from this standpoint that we propose to criticise both our own experiments and those made by other investigators.

It was only after about 14 years' work that we found that the best measure for the value of a tool lay in the exact cutting speed at which it was completely ruined at the end of 20 minutes. In the meantime we had made one set of experiments after another as we successively found the errors due to our earlier standards, and realized and remedied the defects in our apparatus and methods; and we have now arrived at the interesting though rather humiliating conclusion that, with our present knowledge of methods and apparatus, it would be entirely practicable to obtain through four or five years of experimenting all of the information which we have spent 26 years in getting. The following are some of the more important errors made by us:

FINDING OUT WHAT TO AVOID.

We wasted much time by testing tools for a shorter cutting period than 20 minutes, and then having found that tools which were apparently uniform in all respects gave most erratic results (particularly in cutting steel) when run for a shorter period than 20 minutes we erred in the other direction by running our tools for periods of 30 or 40 minutes each, and in this way used up in each single experiment so much of the forging that it was impossible to make enough experiments in cutting metal of uniform quality to get conclusive results. We finally settled on a run of 20 minutes as being the best all-round criterion, and have seen no reason for modifying this conclusion up to date.

We next thought a proper criterion for judging the effect of a given element upon the cutting speed lay in determining the particular cutting speed which would just cause a tool to be slightly discolored below the cutting edge at the end of 20 minutes. After wasting six months in experimenting with this as our standard we found that it was not a true measure, and then adopted as a criterion a certain definite dulling or rubbing away of the cutting edge. Later it was found, however, that each thickness of feed had corresponding to it a certain degree of dullness or injury to the cutting edge at which point regrinding was necessary (the thicker the shaving the duller the tool should be before grinding), and a third series of experiments was made with this as a standard. While experimenting on light forgings a standard dullness of tool was used which was just sufficient to push the forging and tool apart and so slightly alter the diameter of the work. All of these criterions were discarded, however, when in 1894 we finally hit upon the true standard, above described, of completely ruining the tool in 20 minutes. This standard demands both a very large and expensive machine to experiment with, and also large, heavy masses of metal to work upon, which is unfortunate; but we believe without apparatus and methods of this kind it is out of the question accurately to determine the laws which are sought. Experiments upon the art of cutting metals (at least those experiments which have been recorded) have been mainly undertaken by scientific men, mostly by professors. It is but natural that the scientific man should lean toward experiments which require the use of apparatus and that type of scientific observation which is beyond the scope of the ordinary mechanic, or even of engineers unless they have been especially trained in this kind of observation. It is perhaps for this reason more than any other that in this art several of those elements which are of the greatest importance have received no attention

from experimenters, while far less fruitful, although more complicated elements have been the subject of extended experiments. As an illustration of this fact we would call attention to two of the most simple of all of the elements which have been left entirely untouchd by all experimenters—namely:

a. The effect of cooling the tool through pouring a heavy stream of water upon it, which results in a gain of 40 per cent in cutting speed.

b. The effect of the contour or outline of the cutting edge of the tool upon the cutting speed, which when properly designed results in an equally large percentage of gain.

Both of these elements can be investigated at comparatively small cost and with comparatively simple apparatus, while that element which has received chief attention from experimenters—namely, the pressure of the chip on the tool—calls for elaborate and expensive apparatus and is almost barren of useful results. This should be a warning to all men proposing to make experiments in any field, first, to look thoroughly over the whole field and at least carefully consider all of the elements from which any practical results may be expected, and then to select the more simple and elementary of these and properly investigate them before engaging in the more complicated work.

NOTABLE EXPERIMENTS BY OTHERS.

The most notable experiments in this art that have come to the writer's attention are those made at Manchester, England, during the years 1902 and 1903. All these experiments were made jointly by eight of the most prominent English manufacturing companies, among whom were Armstrong, Whitworth & Co., Vickers' Sons & Maxim, John Brown & Co., Thomas Firth & Sons, and others, who combined with the Manchester Association of Engineers and the Manchester Municipal School of Technology, the latter being principally represented by Dr. J. T. Nicholson, who made the final report entitled "Experiments with a Lathe Tool Dynamometer," published in *Transactions*, Vol. 25. In 1901 a committee of the Verein Deutscher Ingenieure (Union of German Engineers), together with the managers of some of the larger engineering works in Berlin, made an interesting series of experiments which was published September 28, 1901, in the *Zeitschrift des Verein Deutscher Ingenieure* and on November 15, 1905, there were published in Bulletin No. 2 of the University of Illinois, experiments made by Prof. L. P. Breckinridge and Henry B. Dirks.

The work of all these men belongs to the second type of experiments above referred to, in which the joint effect of two or more variables is studied at the same time. In the case of the Manchester experiments, the work appears to have been, to a considerable extent, a test as to the all-round knowledge in the art of cutting metals possessed by eight of the prominent English firms. These firms each presented tools made from their own tool steel, treated their own way, and ground to whatever shapes and angles the particular company considered would do the largest amount of work. Each company was allowed to have one guess on each of the qualities of metal worked upon, with each change of feed and depth of cut, as to the cutting speed at which they believed their tool would do the most work. If, under this cutting speed, the tool failed to hold out throughout the stipulated period of time, they were then given no opportunity to find the exact cutting speed at which the tool would do its best work. And, on the other hand, in those cases in which a tool did good work throughout its specified period of time no effort was made to find how much faster it could have run and still do good work. Great variety was shown in the shapes of the tools used in the experiments, yet no effort was made to definitely determine which make of tool steel or which shape

of the tool was best, or even in case a tool did exceptionally good work no effort was made to determine whether this was due to the shape of the tool or to the quality and treatment of the tool steel.

DISCOVERIES MADE WHICH WERE NOT LOOKED FOR.

It is a noteworthy fact that when thorough investigations are attempted by earnest men in new fields, while frequently the object aimed at is not attained, yet quite often discoveries are made which are entirely foreign to the purpose for which the investigation was undertaken. And it may be said that the indirect results of careful scientific work are, generally speaking, fully as valuable as the direct. Two interesting illustrations of this fact have been furnished by our experiments.

The discovery of the Taylor-White process of treating tools by heating them almost to the melting point, or, in other words, the introduction of modern high speed tools the world over, was the indirect result of one of our lines of investigation. The demonstration of the fact that the rules for using belting in common practice furnished belts which were entirely too light for economy was also one of the indirect results of our experiments. The manner of making these discoveries was each time in a way so typical of what may be expected in similar cases that it would seem worth while to describe it in some detail.

During the winter of 1894-1895, the writer conducted an investigation in the shop of Wm. Sellers & Co., at the joint expense of William Cramp & Sons, shipbuilders, and Wm. Sellers & Co., to determine which make of self-hardening tool steel was, on the whole, the best to adopt as standard for all of the roughing tools of these two shops.

As a result of this work the choice was narrowed down at that time to two makes of tool steel: (1) the celebrated Mushet self-hardening steel, the chemical composition of the particular bar analyzed at this time showing tungsten, per cent, 5.441, chromium 0.398, carbon 2.150, manganese 1.578, silicon 1.044, no phosphorus and no sulphur; and (2) a self-hardening steel made by the Midvale Steel Company, having tungsten, per cent, 7.723, chromium 1.830, carbon 1.143, manganese 0.180, silicon 0.246, phosphorus 0.023, and sulphur 0.008.

Of these two steels the tools made from the Midvale steel were shown to be capable of running at rather higher cutting speeds. The writer himself heated hundreds of tools of these makes in the course of his experiments in order to determine accurately the best temperatures for forging and heating them prior to grinding, so as to get the best cutting speeds. In these experiments he found that the Mushet steel if overheated crumbled badly when struck even a light blow on the anvil, while the Midvale steel if overheated showed no tendency to crumble, but, on the other hand, was apparently permanently injured. In fact, heating these tools slightly beyond a bright cherry red caused them permanently to fall down in their cutting speeds, and the writer was unable at that time to find any subsequent heat treatment which would restore a tool broken down in this way to its original good condition. This defect in the Midvale tools left us in doubt as to whether the Mushet or the Midvale was, on the whole, the better to adopt as a shop standard.

HEAT TREATMENT EXPERIMENTS.

In the summer of 1898, soon after undertaking the reorganization of the management of the Bethlehem Steel Company, the writer decided to continue the experiments just referred to, with a view to ascertaining whether in the meanwhile some better tool steel had not been developed. After testing several additional makes of tools our experiments indicated that the Midvale self-hardening tools could be run, if properly heated, at slightly higher speeds than those of any other make.

Upon deciding to adopt this steel as our standard the writer had a num-

ber of tools of each make of steel carefully dressed and ground to exactly the same shape. He then called the foremen and superintendents of the machine shops of the Bethlehem Steel Company to the experimental lathe so that they could be convinced by seeing an actual trial of all of the tools that the Midvale steel was, on the whole, the best. In this test, however, the Midvale tools proved to be worse than those of any other make; *i. e.*, they ran at slower cutting speeds. This result was rather humiliating to us as experimenters who had spent several weeks in the investigation.

It was of course the first impression of the writer that these tools had been overheated in the smith shop. Upon careful inquiry among the smiths, however, it seemed as though they had taken special pains to dress them at a low heat, although the matter was left in much doubt. The writer, therefore, determined to make a thorough investigation before finally adopting the Midvale steel as our shop standard, to discover if possible some heat treatment which would restore Midvale tools injured in their heating (whether they had been underheated or overheated) to their original good condition.

For this purpose Mr. White and the writer started a carefully laid out series of experiments, in which tools were to be heated at temperatures increasing, say, by about 50 degrees all the way from a black heat to the melting point. These tools were then to be ground and run in the experimental lathe upon a uniform forging, so as to find:

a. That heat at which the highest cutting speed could be attained (which our previous experiments had shown to be a cherry red);

b. To determine accurately the exact danger point at which if over or underheated these tools were seriously injured;

c. To find some heat treatment by which injured tools could be restored to their former high cutting speeds.

HEATING TOOLS CLOSE TO THE MELTING POINT.

These experiments corroborated our Cramp-Sellers experiments, showing that the tools were seriously broken down or injured by overheating say, somewhere between 1500 degrees F. and 1700 degrees F.; but to our great surprise tools heated up to or above the high heat of 1725 degrees F. proved better than any of those heated to the best previous temperature, namely, a bright cherry red; and from 1725 degrees F. up to the incipient point of fusion of the tools, the higher they were heated the higher the cutting speeds at which they would run.

Thus, the discovery that phenomenal results could be obtained by heating tools close to the melting point, which was so completely revolutionary and directly the opposite of all previous heat treatment of tools, was the indirect result of an accurate scientific effort to investigate as to which brand of tool steel was, on the whole, the best to adopt as a shop standard, neither Mr. White nor the writer having the slightest idea that overheating beyond the bright cherry red would do anything except injure the tool more and more the higher it was heated.

HEAVY BELTS FOUND DESIRABLE.

During our early Midvale Steel Company experiments, extending from 1880 to 1883, the writer had so much trouble in maintaining the tension of the belt used in driving the boring mill upon which he was experimenting that he concluded: (1) That belting rules in common use furnished belts entirely too light for economy; and (2) that the proper way to take care of belting was to have each belt in a shop tightened at regular intervals with belt clamps especially fitted with spring balances, with which the tension of the belt was accurately weighted every time it was tightened, each belt being retightened each time to exactly the same tension.

In 1884 the writer designed and superintended the erection of a new

machine shop for the Midvale Steel Company, and this gave him the opportunity to put these conclusions to a practical test. About half the belts in the shop were designed according to the ordinary rules and the other half were made about three times as heavy as the usual standard. This shop ran day and night. The belts were in all cases cared for and retightened only upon written orders sent from the shop office; and an accurate record was kept through nine years of all items of interest concerning each belt, namely, the number of hours lost through interruption to manufacture; the number of times each belt interrupted manufacture; the original cost of each belt; the detail costs of tightening, cleaning and repairing each belt; the fall in the tension before requiring retightening; and the time each belt would run without being retightened. Thus at the end of nine years these belts furnished a record which demonstrated beyond question many important facts connected with the use of belting, the principal of these being that the ordinary rules gave belts only about one-half as heavy as should be used for economy.[2] This belting experiment illustrates again the good that often comes indirectly from experiments undertaken in an entirely different field.

SHOP MANAGEMENT.

After many years of close personal contact with our mechanics I have great confidence in their good judgment and common sense in the long run, and I am proud to number many of them among my most intimate friends. As a class, however, they are extremely conservative, and if left to themselves their progress from the older toward better methods will be exceedingly slow. And my experience is that rapid improvement can only be brought about through constant and heavy pressure from those who are over them. It must be said, therefore, that to get any great benefit from the laws derived from these experiments our slide rules must be used, and these slide rules will be of but little, if any, value under the old style of management, in which the machinist is left with the final decision as to what shape of tool, depth of cut, speed, and feed he will use. The slide rules cannot be left at the lathe to be banged about by the machinist. They must be used by a man with reasonably clean hands, and at a table or desk, and this man must write his instructions as to speed, feed, depth of cut, etc., and send them to the machinist well in advance of the time that the work is to be done. Even if these written instructions are sent to the machinist, however, little attention will be paid to them unless rigid standards have been not only adopted, but enforced throughout the shop for every detail, large and small, of the shop equipment, as well as for all shop methods. And further, but little can be accomplished with these laws unless the old style foreman and shop superintendent have been done away with and functional foremanship has been substituted—consisting of speed bosses, gang bosses, order-of-work men, inspector, time study men, etc. In fact, the correct use of slide rules involves the substitution of our whole task system of management for the old style management, as described in our paper on "Shop Management" (*Transactions*, Vol. 24). This involves such radical, one might almost say revolutionary, changes in the mental attitude and habits, both of the workmen and of the man-

[2] The writer presented a paper to this society in 1893 (published in *Transactions*, Vol. 15) upon this series of experiments. He has since found, however, that in the minds of many readers the value of the conclusions arrived at have been seriously brought into question, largely through the criticism of one man, which at the time appeared to the writer so ridiculous that he made the mistake of thinking it not worth answering in detail. This should be a warning to writers to answer carefully all criticisms, however foolish.

agement, and the danger from strikes is so great and the chances for failure are so many, that such a reorganization should only be undertaken under the direct control (not advice but control) of men who have had years of experience and training in introducing this system.

MACHINE SHOP OUTPUT CAN BE DOUBLED.

A long time will be required in any shop to bring about this radically new order of things; but in the end the gain is so great that I say without hesitation that there is hardly a machine shop in the country whose output cannot be doubled through the use of these methods. And this applies not only to large shops, but also to comparatively small establishments. In a company whose employes all told, including officers and salesmen, number about 150 men, we have succeeded in more than doubling the output of the shop, and in converting an annual loss of 20 per cent upon the old volume of business into an annual profit of more than 20 per cent upon the new volume of business, and at the same time rendering a lot of disorganized and dissatisfied workmen contented and hard working, by insuring them an average increase of about 35 per cent in their wages. And I take this opportunity of again saying that those companies are indeed fortunate who can secure the services of men to direct the introduction of this type of management who have had sufficient training and experience to insure success.[1]

Unfortunately those fundamental ideas upon which the new task management rests mainly for success are directly antagonistic to the fundamental ideas of the old type of management. To give two out of many examples: Under our system the workman is told minutely just what he is to do and how he is to do it; and any improvement which he makes upon the orders given him is fatal to success. While, with the old style, the workman is expected constantly to improve upon his orders and former methods, under our system any improvement, large or small, once decided upon goes into immediate use and is never allowed to lapse or become obsolete, while under the old system the innovation unless it meets with the approval of the mechanic (which it never does at the start) is generally for a long time, at least, a positive impediment to success. Thus many of those elements which are mainly responsible for the success of our system are failures and a positive clog when grafted on the old system.

For this reason the really great gain which will ultimately come from the use of these slide rules will be slow in arriving—mainly, as explained, because of the revolutionary changes needed for their successful use—but it is sure to come in the end.

STANDARDIZATION MEANS SIMPLIFICATION.

Too much emphasis cannot be laid upon the fact that standardization really means simplification. It is far simpler to have in a standardized shop two makes of tool steel than to have 20 makes of tool steel, as will be found in shops under the old style of management. It is far simpler to have all of the tools in a standardized shop ground by one man to a few simple but rigidly maintained shapes than to have, as is usual in the old style shop, each machinist spend a portion of each day at the grindstone, grinding his tools with radically wrong curves and cutting angles, merely because bad shapes are easier to grind than good. Hundreds of similar illustration could be given showing the true simplicity (not complication) which accompanies the new type of management.

---

[1] The writer feels free to give this advice most emphatically without danger of having his motives misinterpreted, since he has himself given up accepting professional engagements in this field.

There is, however, one element in which the new type of management in all outward appearance is far more complicated than the old—namely, no standards and no real system of management can be maintained without the supervision, and, what is more, the hard work of men who would be called by the old style of management supernumeraries or nonproducers. The man who judges of the complication of his organization only by looking over the names of those on the payroll and separating the so-called nonproducers from the producers, finds the new style of management more complicated than the old.

No one doubts for one minute that it is far simpler to run a shop with a boiler, steam engine, shafting, pulleys and belts than it would be to run the same shop with the old fashioned foot power, yet the boiler, steam engine, shafting, pulleys and belts require as supernumeraries or nonproducers on the payroll, a fireman, an engineer, an oiler and often a man to look after belts. The old style manager, however, who judges of complication only by comparing the number of nonproducers with that of the producers, would find the steam engine merely a complication in management. The same man, to be logical, would find the whole drafting force of an engineering establishment merely a complication, whereas in fact it is a great simplification over the old method.

A HUMAN MANAGING MACHINE NEEDED.

Now our whole system of management is quite accurately typified by the substitution of an elaborate engine to drive and control the shop in place of the old-fashioned foot power. There is no question that our human managing machine, which is required for the maintenance and the effective use of both standard shop details and standard methods throughout the establishment, calls for many more nonproducers than are used with the old style management, having its two or three foremen and a superintendent. The efficiency of our engine of management, however, compared with the old single foremen, is like a shop engine as compared with foot power, or the drafting room as compared with having the designing done by the patternmaker, blacksmith, and machinist.

A study of the recommendations made throughout this paper will illustrate the fact that we propose to take all of the important decisions and planning, which vitally affect the output of the shop, out of the hands of the workmen and centralize them in a few men, each of whom is especially trained in the art of making those decisions and in seeing that they are carried out, each man having his own particular function in which he is supreme, and not interfering with the functions of other men.

INDEPENDENT MOTORS CRITICISED.

There is one recommendation, however, in modern machine shop practice, in making which the writer will probably be accused of being old fashioned or ultra conservative. Of late years there has been what may be almost termed a blind rush on the part of those who have wished to increase the efficiency of their shops toward driving each individual machine with an independent motor. The writer is firmly convinced through large personal observation in many shops and through having himself systematized two electrical works that in perhaps three cases out of four a properly designed belt drive is preferable to the individual motor drive for machine tools. There is no question that through a term of years the total cost, on the one hand, of individual motors and electrical wiring, coupled with the maintenance and repairs of this system, will far exceed the first cost of properly designed shafting and belting plus maintenance and repairs (in most shops entirely too light belts and countershafts of inferior design are used, and the belts are not systematically cared for by one trained man, and this involves a heavy cost for maintenance).

It is at last admitted that there is little, if any, economy in power obtainable through promiscuous motor driving, and it will certainly be found to be a safe rule not to adopt an individual motor for driving any machine tool unless clearly evident that a large saving can be made by it.

AN ERA OF TRUE CO-OPERATION.

In concluding let me say that we are now but on the threshold of the coming era of true co-operation. The time is fast going by for the great personal or individual achievement of any one man standing alone and without the help of those around him. And the time is coming when all great things will be done by the co-operation of many men, in which each man performs that function for which he is best suited, each man preserves his own individuality and is supreme in his particular function and each man at the same time loses none of his originality and proper personal initiative and yet is controlled by and must work harmoniously with many other men.

And let me point out that the most important lessons taught by these experiments, particularly to the younger men, are: Several men when heartily co-operating, even if of everyday caliber, can accomplish what would be next to impossible for any one man, even of exceptional ability. Expensive experiments can be successfully carried on by men without money, and the most difficult mathematical problems can be solved by very ordinary mathematicians, providing only that they are willing to pay the price in time, patience and hard work. The old adage is again made good, that all things come to him who waits, if only he works hard enough in the meantime.

BOOK NOTICES

"Fighting Fleets for 1907." 6th edition. 784 pages and 359 diagrams of ships. Berger-Levrault and Co. Paris, 5 Rue des Beaux-Arts. Price, 5 francs.

One of the immediate consequences of the Russo-Japanese war, and of the political events which have followed it, has been to call attention in all countries to the greater and greater influence which naval force exercises among nations. Never has an exact knowledge of the strengths of navies been so important as to-day.

Consequently the appearance of a new edition of the well-known work of Commander Balincourt is an event of interest and of importance.

The author gives, in a judiciously condensed form and in the alphabetical order of the nations, the most complete and precise data regarding the units of the fighting fleets of all the naval powers. Moreover, at the head of the part treating of each power, the reader will find a brief account of the general organization of the squadrons of that power and of the relative value which should be assigned to them. The diagrams, more than 350 in number, showing the types of all the fighting units, help greatly to elucidate the text.

We will add that this book is small enough to be easily carried in the pocket—a valuable quality in such a publication,—and that it will surely meet with a success equal to that of the preceding editions, which in every case have been exhausted within a few months of their appearance.

"Internal Combustion Engines." An Elementary Treatise on Gas, Gasoline, and Oil Engines, for the Instruction of Midshipmen at the Naval Academy. By John K. Barton, Commander, U. S. Navy. Size 5½ x 9 inches. Pages 135 with 52 illustrations. Price $1.50. U. S. Naval Institute, Annapolis, Md.

This little work covers in a condensed form, in half a dozen chapters, the subjects indicated in the title.

Chapter I explains the leading characteristics of gas and oil engines with their essential parts very clearly illustrated by cuts.

Chapter II treats of a number of the principal types and the advantages and disadvantages peculiar to each.

Chapter III describes the fuels used, both gas and oil, their sources and relative heat values. Also suction gas producers.

Chapter IV enters into the details of oil engines, with cuts fully illustrating the construction of all parts of several types of engines, selected as representative of their class.

Chapter V gives some necessary instruction on the subject of engine tests and a form for tabulating the data.

Chapter VI treats of the practical operation of the various engines, the causes of their failure to work, and explains how to locate troubles. It has also some timely information on the subject of "denatured alcohol" which is about to become an important factor in the economics of many industrial arts in this country. The chapter concludes with a description of what is an interesting, because apparently a practical and successful, gas turbine.

There are several useful appendices, a cut and description of a very accurate water brake, a description of the method of calibrating the instruments used in making engine tests, together with a list of books and magazines to which the reader is referred for further information.

The book is well illustrated throughout, and its style clear and concise. It will be found a convenient hand-book for officers who wish to get a good working knowledge of the essential particulars of the leading types of engines, the purposes for which they are adapted, the fuels used, and yet who can not spend much time on the subject.

Owing to the rapidly increasing importance to naval officers of the subjects treated the book should be well received throughout the service.

W. F. W.

"Altitude, Azimuth, and Geographical Position." By G. W. Littlehales, C. E.

The object of the graphical tables for the solution of the astronomical triangle is so clearly expressed by the author in a brief preface, that a portion of it is here quoted.

"The object held in view in this work is not only to simplify and shorten the labors of scientific navigators and geographical explorers, but to open to all navigators the field of astronomical navigation which has heretofore been restricted to those of higher education. But the practical seaman has little leisure, even if he has the taste, for long numerical computations, and in seeking to satisfy the demands for processes that are brief and yet accurate within the requirements of navigation, logarithmic, and numerical computations have been almost swept away in the present method. The subject of identifying the celestial body that has been observed, and of simultaneously finding the true bearing and sumner line of geographical position with as much precision as astronomical observations taken at sea will warrant, is here treated as if the co-ordinates of the celestial sphere had been tabulated from minute to minute of arc throughout the whole circuit of the heavens in such manner that the table, being entered with the latitude of the observer and the hour angle and declination of the observed celestial body, would give the corresponding altitude and azimuth of the observed body." . . . . "It will appear, upon an examination of this method, that a sure and simple solution is here provided with reference to all the problems of navigation and astronomy that depend upon the solution of a spherical triangle in which two sides and the included angle are given."

To accomplish these objects a stereographic projection of a sphere of *twelve* feet radius was made, and owing to the inconvenience of using a

chart of such dimensions, each quadrant divided into ninety-two overlapping, small charts, on the same scale. These 368 charts, two on each page, are the graphic tables referred to in the preface, from which the altitude and azimuth are finally, but not directly taken, as two separate charts must be entered before the desired results are obtained.

From the results of several trials, I find that the accuracy of the result is about the same as could be obtained from a computation of the same problem, using *four* place logarithms, an accuracy sufficient for navigation. The use of the small charts with two systems of intersecting curves is trying to the eye, so much so, that the educated navigator might prefer the ordinary methods of computation with logarithms.

So far as concerns the use of the "Method of St. Hilaire" for finding the line of position from *one* assumed latitude and longitude, the tables are valuable, but the same method may be used with the same advantage when the altitude and azimuth are derived by the ordinary logarithmic computation.

If the graphical tables are eventually adopted for general use in navigation, their value would be greatly increased by printing each chart on a separate page, the whole to be kept in a suitable index drawer, where the two charts desired could be easily withdrawn and again restored. Like all other aids to navigation, their general adoption will depend upon the verdict of the practical navigator after trial. There will be many who will find the logarithmic work preferable from any point of view, accuracy, convenience or ease, as there may be many others who will find the graphical method sufficient to their needs, and in harmony with their mathematical tastes.

Whatever their fate, the author deserves great credit for the successful prosecution of a task involving enormous labor. S. J. B.

(Philadelphia. J. B. Lippincott. 1906.)

"The Steam Engine." By W. H. P. Creighton, U. S. N. (Retired), Professor of Engineering, Tulane University. Size 9 x 5½ inches. Pages 490.

The purpose of the author in the preparation of this book is to furnish a treatise adapted to undergraduate students of college grade. The book is divided into eighteen chapters, and starts off with a bird's-eye view of the general subject of engineering, with illustrations of the main elements of a steam engine plant, and the general relations of the different forms of energy. Following this, the remainder of the book deals with indicators, indicating engines, curves, and work of expansion; Zeuner and Bilgram valve diagrams and the design of slide valves; heat and heat losses, entropy; the auxiliaries of the steam engine; the principles of condensers and the multiple expansion engine; speed variation, revolution control and engine balancing; engine tests; superheated steam and steam turbines; gas engines; evaporation and refrigeration.

An attempt has been made by the author to cover a very large field within a limited space, consequently in a cursory manner, and under some of the headings one might wish for a fuller and broader treatment. To

cover the wide range of topics, a selection has had to be made from the very large amount of material available, and to present briefly those seeming best suited to the needs of the student. In making these selections, the author has shown great care and good judgment.

In general, and within the scope intended by the author, namely, a book for the use of undergraduate college students in mechanical engineering, where the work can be supplemented by both class room and laboratory instruction, the treatment of the subject is carefully done and clear for the purpose intended.

The general make up of the book is good, well printed, the illustrations frequent and well selected and executed. J. K. B.

(John Wiley and Sons, New York. Price $5.00.)

ANNUAL REPORT OF THE SECRETARY AND TREASURER OF THE U. S. NAVAL INSTITUTE.

To the Officers and Members of the Institute:

Gentlemen:—I have the honor to submit the following report for the year ending December 31, 1906.

Itemized Cash Account.

Receipts During the Year 1906.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Dues	$ 360 00	$1,210 56	$ 327 50	$ 198 00	$2,096 06
Subscriptions	480 60	188 26	224 68	265 62	1,159 16
Extra publications	4,749 54	4,596 09	3,890 83	9,464 22	22,700 68
Sale of Proceedings	124 04	35 91	28 38	63 45	251 78
Advertisements	601 50	232 50	236 00	404 25	1,474 25
Interest on investments	388 44	139 37	238 75	294 73	1,061 29
Postage	2 65	4 36	99	2 15	10 15
Expressage	36	41	56	1 76	3 09
Binding	1 00	19 00	....	2 00	22 00
Life fee	30 00	....	....	....	30 00
Premium on money orders	....	05	16	08	29
Credits	....	....	1 10	71	1 81
Northern Pacific Bonds	....	....	....	4,507 50	4,507 50
Discount on draft	....	....	....	85	85
Totals	$ 6,738 13	$ 6,426 51	$ 4,948 95	$15,205 32	$33,318 91

EXPENDITURES DURING THE YEAR 1906.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Printing and binding Proceedings	$1,043 27	$ 904 05	$1,218 02	$1,157 50	$3,469 61
Printing and binding extra publications	949 51	1,905 75	4,933 87	4,527 22	13,169 58
Paid contributors	604 52	101 00	667 00	587 00	1,959 52
*Salaries	585 00	585 00	585 00	765 00	2,520 00
Postage	98 49	112 68	104 57	122 33	438 07
Freight and hauling	1 25	2 51	85	2 35	6 96
Stationery	55	4 60	12 08	48 19	65 42
Purchase of back numbers of Proceedings	8 75	....	28 00	....	36 75
Expressage	23 40	36 61	14 45	25 63	100 09
Paid authors of books	200 00	241 20	100 00	1,328 00	1,869 20
Prize Essay and medal	216 25	11 00	....	....	227 25
Telegrams	2 74	3 85	1 31	1 96	9 86
Typewriting	38 50	71 05	....	9 00	118 55
Commission to advertising agent	200 00	....	50 00	....	250 00
Office expense	6 07	27	1 50	7 05	14 89
Rose Commercial Agency	12 50	7 50	....	....	20 00
Purchase of books	....	6 70	1 00	19 35	27 05
Advertising	....	26 28	50 50	....	76 78
Rent of safe box	....	5 00	....	....	5 00
Discount on drafts and money orders	....	12	25	64	1 01
Insurance	...	....	79 50	49 45	128 95
Purchase of books for resale	....	....	....	36 00	36 00
Purchase of bonds	...	....	....	4,507 50	4,507 50
Totals	$3,990 80	$4,025 17	$7,847 90	$13,194 17	$29,058 04

*The salary of the Secretary and Treasurer was increased to $900.00 for the year 1906, by action of the Board of Control at a meeting of the Board, held December 11, 1906. The salaries per month are as follows: Secretary and Treasurer $75.00; Clerk $110.00; Messenger $25.00.

SUMMARY.

Balance of cash unexpended January 1, 1906	$21,928 97
Total receipts for the year 1906	33,318 91
Total available cash for the year 1906	$55,247 88
Total expenditures for the year 1906	29,058 04
Cash balance unexpended January 1, 1907	$26,189 84

SUMMARY—*Continued.*

Amount brought forward	$26,189.84
Bills receivable for back dues	1,316.02
" " " binding	11.80
" " " subscriptions	57.40
" " " extra publications	1,104.60
" " " Proceedings	5.63
" " " advertisements	680.00
Value of back numbers of the Proceedings	300.00
" " Institute property, furniture	200.00
" " extra publications, electrotype plates, etc.	1,800.00
	$31,665.29
Liabilities	189.30
Total assets	$31,475.99

RESERVE FUND.

Baltimore & Ohio and Northern Pacific bonds	$4,623.14

The cash balance, $26,189.84, unexpended January 1, 1907, is distributed as follows:

Deposited in Seamen's Bank for Savings, New York	$3,000.00
" with Rhode Island Hospital Trust Co., Providence, Rhode Island	2,403.20
" with Society for Savings, Hartford, Conn.	2,438.34
Southern Railway bonds	2,266.25
Washington Electric Railway bonds	1,715.00
Northern Pacific and Great Northern bonds	5,027.50
Potomac Electric Power Co.'s bonds	2,115.00
Northern Pacific Railway bonds	4,507.50
Baltimore & Ohio bonds	589.36
In Farmers' National Bank, Annapolis, Maryland	2,057.26
Cash in safe, Naval Institute office	70.43
	$26,189.84

Respectfully,
PHILIP R. ALGER, *Professor U. S. Navy,*
Secretary and Treasurer.

The books of the Institute have been examined from February 1, 1906, to February 9, 1907, and found to be correct, and the balance sheets verified.

Auditing Committee:

A. W. GRANT, Commander U. S. Navy.
H. J. ZIEGEMEIER, Lieut.-Commander U. S. Navy.
N. M. TERRY, Professor A. M., Ph. D.

LIST OF PRIZE ESSAYS.

1879.

Naval Education. Prize Essay, 1879. By Lieut.-Com. A. D. Brown, U. S. N.

NAVAL EDUCATION. First Honorable Mention. By Lieut.-Com. C. F. Goodrich, U. S. N.

NAVAL EDUCATION. Second Honorable Mention. By Commander A. T. Mahan, U. S. N.

1880.

"The Naval Policy of the United States." Prize Essay, 1880. By Lieutenant Charles Belknap, U. S. N.

1881.

The Type of (I) Armored Vessel, (II) Cruiser best suited to the Present Needs of the United States. Prize Essay, 1881. By Lieutenant E. W. Very, U. S. N.

SECOND PRIZE ESSAY, 1881. By Lieutenant Seaton Schroeder, U. S. N.

1882.

Our Merchant Marine: The Causes of its Decline and the Means to be taken for its Revival. "Nil clarius aquis." Prize Essay, 1882. By Lieutenant J. D. J. Kelley, U. S. N.

"MAIS IL FAUT CULTIVER NOTRE JARDIN." Honorable Mention. By Master C. G. Calkins, U. S. N.

"SPERO MELIORA." Honorable Mention. By Lieut.-Com. F. F. Chadwick, U. S. N.

"CAUSA LATET: VIS EST NOTISSIMA." Honorable Mention. By Lieutenant R. Wainwright, U. S. N.

1883.

How may the Sphere of Usefulness of Naval Officers be extended in Time of Peace with Advantage to the Country and the Naval Service? "Pour encourager les Autres." Prize Essay, 1883. By Lieutenant Carlos G. Calkins, U. S. N.

"SEMPER PARATUS." First Honorable Mention. By Commander N. H. Farquhar, U. S. N.

"CUILIBET IN ARTE SUA CREDENDUM EST." Second Honorable Mention. By Captain A. P. Cooke, U. S. N.

1884.

The Reconstruction and Increase of the Navy. Prize Essay, 1884. By Ensign W. I. Chambers, U. S. N.

1885.

Inducements for Retaining Trained Seamen in the Navy, and Best System of Rewards for Long and Faithful Service. Prize Essay, 1885. By Commander N. H. Farquhar, U. S. N.

1886.

What Changes in Organization and Drill are Necessary to Sail and Fight Effectively Our Warships of Latest Type? "Scire quod nescias." Prize Essay, 1886. By Lieutenant Carlos G. Calkins, U. S. N.

THE RESULT OF ALL NAVAL ADMINISTRATION AND EFFORTS FINDS ITS EXPRESSION IN GOOD ORGANIZATION AND THOROUGH DRILL ON BOARD OF SUITABLE SHIPS. Honorable Mention. By Ensign W. L. Rodgers, U. S. N.

1887.

The Naval Brigade: its Organization, Equipment and Tactics. "In hoc signo vinces." Prize Essay, 1887. By Lieutenant C. T. Hutchins,

1888.

Torpedoes. Prize Essay, 1888. By Lieut.-Com. W. W. Reisinger, U.S.N

1891.

The Enlistment, Training and Organization of Crews for our Ships of War. Prize Essay, 1891. By Ensign A. P. Niblack, U.S.N.

DISPOSITION AND EMPLOYMENT OF THE FLEET: SHIP AND SQUADRON DRILL. Honorable Mention, 1891. By Lieutenant R. C. Smith, U.S.N.

1892.

Torpedo-boats: their Organization and Conduct. Prize Essay, 1892. By Wm. Laird Clowes.

1894.

The U.S.S. Vesuvius, with Special Reference to her Pneumatic Battery. Prize Essay, 1894. By Lieut.-Com. Seaton Schroeder, U.S.N.

NAVAL REFORM. Honorable Mention, 1894. By Passed Assistant Engineer F. M. Bennett, U.S.N.

1895.

Tactical Problems in Naval Warfare. Prize Essay, 1895. By Lieut.-Com. Richard Wainwright, U.S.N.

A SUMMARY OF THE SITUATION AND OUTLOOK IN EUROPE. An Introduction to the Study of Coming War. Honorable Mention, 1895. By Richmond Pearson Hobson, Assistant Naval Constructor, U.S.N.

SUGGESTIONS FOR INCREASING THE EFFICIENCY OF OUR NEW SHIPS. Honorable Mention, 1895. By Naval Constructor Wm. J. Baxter, U.S.N.

THE BATTLE OF THE YALU. Honorable Mention, 1895. By Ensign Frank Marble, U.S.N.

1896.

The Tactics of Ships in the Line of Battle. Prize Essay, 1896. By Lieutenant A. P. Niblack, U.S.N.

THE ORGANIZATION, TRAINING AND DISCIPLINE OF THE NAVY PERSONNEL AS VIEWED FROM THE SHIP. Honorable Mention, 1896. By Lieutenant Wm. F. Fullam, U.S.N.

NAVAL APPRENTICES, INDUCEMENTS, ENLISTING AND TRAINING. The Seaman Branch of the Navy. Honorable Mention, 1896. By Ensign Ryland D. Tisdale, U.S.N.

THE COMPOSITION OF THE FLEET. Honorable Mention, 1896. By Lieutenant John M. Ellicott, U.S.N.

1897.

Torpedo-boat Policy. Prize Essay, 1897. By Lieutenant R. C. Smith, U.S.N.

A PROPOSED UNIFORM COURSE OF INSTRUCTION FOR THE NAVAL MILITIA. Honorable Mention, 1897. By H. G. Dohrman, Associate Member, U.S.N.I.

TORPEDOES IN EXERCISE AND BATTLE. Honorable Mention, 1897. By Lieutenant J. M. Ellicott, U. S. N.

1898.

Esprit de Corps: A Tract for the Times. Prize Essay, 1898. By Captain Caspar Frederick Goodrich, U.S.N.

OUR NAVAL POWER. Honorable Mention, 1898. By Lieut.-Com. Richard Wainwright, U.S.N.

TARGET PRACTICE AND THE TRAINING OF GUN CAPTAINS. Honorable Mention, 1898. By Ensign R. H. Jackson, U.S.N.

1900.

Torpedo Craft: Types and Employment. Prize Essay, 1900. By Lieutenant R. H. Jackson, U.S.N.

THE AUTOMOBILE TORPEDO AND ITS USES. Honorable Mention, 1900. By Lieutenant L. H. Chandler, U.S.N.

1901.

Naval Administration and Organization. Prize Essay, 1901. By Lieutenant John Hood, U.S.N.

1903.

Gunnery in Our Navy. The Causes of its Inferiority and Their Remedies. Prize Essay, 1903. By Professor Philip R. Alger, U.S.N.

A NAVAL TRAINING POLICY AND SYSTEM. Honorable Mention, 1903. By Lieutenant James H. Reid, U.S.N.

SYSTEMATIC TRAINING OF THE ENLISTED PERSONNEL OF THE NAVY. Honorable Mention, 1903. By Lieutenant C. L. Hussey, U.S.N.

OUR TORPEDO-BOAT FLOTILLA. The Training Needed to Insure its Efficiency. Honorable Mention, 1903. By Lieutenant E. L. Beach, U.S.N.

1904.

The Fleet and its Personnel. Prize Essay, 1904. By Lieutenant S. P. Fullinwider, U. S. N.

A PLEA FOR A HIGHER PHYSICAL, MORAL, AND INTELLECTUAL STANDARD OF THE PERSONNEL FOR THE NAVY. Honorable Mention, 1904. By Medical Inspector Howard E. Ames, U. S. N.

1905.

American Naval Policy. Prize Essay, 1905. By Commander Bradley A. Fiske, U. S. N.

THE DEPARTMENT OF THE NAVY. Honorable Mention, 1905. By Rear-Admiral Stephen B. Luce, U. S. N.

1906.

Promotion by Selection. Prize Essay, 1906. By Commander Hawley O. Rittenhouse, U. S. N.

THE ELEMENTS OF FLEET TACTICS. First Honorable Mention, 1906. By Lieut-Com. A. P. Niblack, U. S. N.

GLEANINGS FROM THE SEA OF JAPAN. Second Honorable Mention, 1906. By Captain Seaton Schroeder, U. S. N.

THE PURCHASE SYSTEM OF THE NAVY. Third Honorable Mention, 1906. By Pay Inspector J. A. Mudd, U. S. N.

1907.

Storekeeping at the Navy Yards. Prize Essay, 1907. By Pay Inspector John A. Mudd, U. S. N.

BATTLE REHEARSALS. A few thoughts on our next step in Fleet-Gunnery. First Honorable Mention, 1907. By Lieut.-Comdr. Yates Stirling, U. S. N.

THE NAVAL PROFESSION. Second Honorable Mention, 1907. By Commander Bradley A. Fiske, U. S. N.

NOTICE.

The U. S. Naval Institute was established in 1873, having for its object the advancement of professional and scientific knowledge in the Navy. It now enters upon its thirty-fourth year of existence, trusting as heretofore for its support to the officers and friends of the Navy. The members of the Board of Control cordially invite the co-operation and aid of their brother officers and others interested in the Navy, in furtherance of the aims of the Institute, by the contribution of papers and communications upon subjects of interest to the naval profession, as well as by personal support and influence.

On the subject of membership the Constitution reads as follows:

ARTICLE VII.

Sec. 1. The Institute shall consist of regular, life, honorary, and associate members.

Sec. 2. Officers of the Navy, Marine Corps, and all civil officers attached to the Naval Service, shall be entitled to become regular or life members, without ballot, on payment of dues or fee to the Secretary and Treasurer, or to the Corresponding Secretary of a Branch. Members who resign from the Navy subsequent to joining the Institute will be regarded as belonging to the class described in this Section.

Sec. 3. The Prize Essayist of each year shall be a life member without payment of fee.

Sec. 4. Honorary members shall be selected from distinguished Naval and Military Officers, and from eminent men of learning in civil life. The Secretary of the Navy shall be, *ex officio*, an honorary member. Their number shall not exceed thirty (30). Nominations for honorary members must be favorably reported by the Board of Control, and a vote equal to one-half the number of regular and life members, given by proxy or presence, shall be cast, a majority electing.

Sec. 5. Associate members shall be elected from Officers of the Army Revenue Marine, foreign officers of the Naval and Military professions, and from persons in civil life who may be interested in the purposes of the Institute.

Sec. 6. Those entitled to become associate members may be elected life members, provided that the number not officially connected with the Navy and Marine Corps shall not at any time exceed one hundred (100).

Sec. 7. Associate members and life members, other than those entitled to regular membership, shall be elected as follows: "Nominations shall be made in writing to the Secretary and Treasurer, with the name of the member making them, and such nominations shall be submitted to the Board of Control, and, if their report be favorable, the Secretary and Treasurer shall make known the result at the next meeting of the Institute, and a vote shall then be taken, a majority of votes cast by members present electing."

The Proceedings are published quarterly, and may be obtained by non-members upon application to the Secretary and Treasurer at Annapolis, Md. Inventors of articles connected with the naval profession will be afforded an opportunity of exhibiting and explaining their inventions. A description of such inventions as may be deemed by the Board of Control of use to the service will be published in the Proceedings.

Single copies of the Proceedings, $1.00. Back numbers and complete sets can be obtained by applying to the Secretary and Treasurer, Annapolis, Md.

Annual subscriptions for non-members, $3.50. Annual dues for members and associate members, $3.00. Life members fee, $30.00.

All letters should be addressed to Secretary and Treasurer, U. S. Naval Institute, Annapolis, Md., and all checks, drafts, and money orders should be made payable to his order, without using the name of that officer.

OFFICERS OF THE INSTITUTE.

President.

REAR-ADMIRAL CASPAR F. GOODRICH, U. S. NAVY.

Vice-President.

REAR-ADMIRAL JAMES H. SANDS, U. S. NAVY.

Secretary and Treasurer.

PROFESSOR P. R. ALGER, U. S. NAVY.

Board of Control.

Captain G. P. COLVOCORESSES, U. S. Navy.
Commander W. F. WORTHINGTON, U. S. Navy.
Commander A. W. GRANT, U. S. Navy.
Lieut.-Comd'r H. J. ZIEGEMEIER, U. S. Navy.
Lieutenant RAYMOND STONE, U. S. Navy.
Professor N. M. TERRY, A. M., Ph. D.
Professor PHILIP R. ALGER, U. S. Navy (ex-officio).

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1908.

A prize of two hundred dollars, with a gold medal, and a life-membership in the Institute, is offered by the Naval Institute for the best essay presented on any subject pertaining to the naval profession, subject to the following rules:

1. The award for the prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1908. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Board.

3. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Board.

4. If, in the opinion of the Board of Control, the best essay presented is not of sufficient merit to be awarded the prize, it may receive "Honorable Mention" or such other distinction as the Board may decide.

5. In case one or more essays receive "Honorable Mention," the writer of the first of them in order of merit will receive seventy-five dollars and a life-membership in the Institute.

6. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

7. The essay is limited to fifty (50) printed pages of the Proceedings of the Institute.

8. All essays submitted must be either typewritten or copied in a clear and legible hand.

9. In the event of the prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of the gold medal.

By direction of the Board of Control.

PHILIP R. ALGER,
Professor, U. S. N., Secretary and Treasurer.